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PRINCIPLES OF NUTRITION AND NUTRITIVE VALUE OF FOOD.

[CORRECTED TO APRIL 5, 1906.]

BY

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PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., April 5, 1906.

SIR: I have the honor to transmit herewith an article on Principles of Nutrition and Nutritive Value of Food, by Prof. W. O. Atwater, special agent in charge of nutrition investigations, prepared in accordance with instructions given by the Director of this Office. For a number of years the Department has carried on studies regarding the kinds and amounts of foods consumed by persons of different occupations and with different incomes, the composition of food, the relative cost of nutrients when furnished by different foods, and many more technical questions. The present bulletin discusses the general principles of nutrition, as well as a number of the more important phases of the subject, with special reference to the results obtained in Department investigations and the closely related work of the agricultural experiment stations. As the work has progressed the earlier ideas have been modified, and the present bulletin is designed to supplement and replace earlier Department publications by the author having a similar scope. In preparing this bulletin Professor Atwater has had the assistance of Miss Helen W. Atwater.

The first edition of this bulletin was published several years ago. In preparing this edition for publication a number of changes which seemed desirable have been made.

It is believed that the article is a useful summary of available information on the subject, and its publication as a Farmers' Bulletin is therefore recommended.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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PRINCIPLES OF NUTRITION AND NUTRITIVE VALUE OF FOOD.

INTRODUCTION.

The problem of proper nutrition has always been of great importance, yet scientific study of this subject is comparatively recent. Food investigations have been carried on in Europe for some three-quarters of a century, and for a less time in the United States. In recent years the development of this subject has been very rapid; a large number of investigations have been carried on under the auspices of this Department, the agricultural experiment stations, and various educational institutions, and many facts of interest and importance have been learned. It seems desirable, therefore, to summarize this information, and, so far as possible, to interpret the results in such a way as to show their practical application.

Constant use has made us so familiar with our ordinary foods that we seldom realize how complicated they are; yet a thorough understanding of them takes us far, not only into chemistry, but into physics and physiology as well.

CHEMICAL COMPOSITION OF THE BODY AND OF FOOD.

The chemical substances of which the body is composed are very similar to those of the foods which nourish it. They are made up of the same chemical elements, and hence the two may be discussed together. From fifteen to twenty elements are found, among the most abundant of which are oxygen, hydrogen, carbon, nitrogen, calcium, phosphorus, and sulphur. The elements are so combined as to form a great variety of compounds in both body and food. The most important kinds of compounds in the body and in foods are protein, fats, carbohydrates, mineral matter, and water. The functions of these compounds in the food, as explained in detail later in this bulletin, are to build and repair the various tissues of the body and to supply it with heat and muscular energy.

WATER.

Water is one of the most abundant of these compounds. It forms over 60 per cent of the weight of the body of the average man, being a component part of all the tissues. It is thus an important constituent of our food, though it can not be burned, and hence does not yield energy to the body.

MINERAL MATTER OR ASH.

Other food ingredients which yield little or no energy and are yet indispensable to the body are the mineral matters. They form only 5 or 6 per cent of the body by weight, and are found chiefly in the bones and teeth, but are present also in the other tissues and in solution in the various fluids. When food or body material is burned the mineral constituents remain as ash. Phosphate of lime, or calcium phosphate, is the mineral basis of bone. Numerous compounds of potassium, sodium, magnesium, and iron are found in the body and are necessary to life.

The remaining nutritive materials are organic compounds, so called because they occur principally in the organic, i. e., the animal and vegetable world. They all contain carbon, oxygen, and hydrogen, in varying proportions. Some also contain nitrogen, phosphorus, sulphur, or other elements. Those occurring in the body and in food are divided into three principal groups—protein, fats, and carbohydrates.

PROTEIN.

This term includes the principal nitrogenous compounds. Protein is familiar to us in the lean and gristle of meat, the white of eggs, the gluten of wheat, etc. It forms about 18 per cent, by weight, of the body of the average man. Protein compounds may be subdivided into albuminoids, gelatinoids, and extractives. The first group, the albuminoids, include substances similar to the white of egg, the lean of meat (myosin), the curd of milk (casein), and the gluten of wheat. The second group, the gelatinoids,[a] occur principally in the connective tissues, such as the collagen of the tendons and skin and the ossein of bone.

The albuminoids and gelatinoids, classed together as proteids, are most important constituents of our food. They make the basis of bone, muscle, and other tissues, and are essential to the body structure. They are also used as fuel—that is, they are burned in the body to yield energy—and they are to some extent transformed into fat and stored in the body, but these are their less important uses. The pro-

[a] The term albuminoids is often applied to what are here called gelatinoids; the term proteid is used in the same significance; indeed, there is great confusion in the use of these terms by different writers. The terminology here followed is that recommended by the American Association of Agricultural Colleges and Experiment Stations.

tein compounds are most abundant in some of the animal foods, as lean meat, though the cereals contain them in considerable, and peas and beans in large, proportions. The gelatinoids are less valuable than the albuminoids for nutriment.

The third class, the so-called extractives, are included with the protein compounds because they contain nitrogen, but they differ greatly from the albuminoids and gelatinoids. They are the principal ingredients of meat extracts, beef tea, etc. They are believed to neither build tissue nor furnish energy, but to act as stimulants and appetizers. The craving which some persons have for meat is perhaps due in part to a desire for these extractives. The nitrogenous compounds of potatoes and other vegetable foods contain more or less of so-called amids, like asparagin, which are analogous to the extractives of meat, and like them can not build tissue, and hence have an inferior nutritive value.

FATS.

Fats occur chiefly in animal foods, as meats, fish, butter, etc. They are also abundant in some vegetable products, such as olives and cotton seed, from which they are expressed as oil, and occur in considerable quantities in some cereals, notably oatmeal and maize (whole kernel), and in various nuts. In our bodies and those of animals fats occur in masses under the skin and in other localities, and in minute particles scattered through the various tissues. The amount of fat in the body varies greatly with food, exercise, age, and other conditions. When more food is taken than is necessary for immediate use part of the surplus may be stored in the body. The protein and fat of food may thus become body protein and body fat; sugar and starch of food are changed to fat in the body and stored as such. When the food supply is short this reserve material is drawn upon for supplementary fuel. Fat forms about 15 per cent, by weight, of the body of an average man. Well-fed or overfed people with little muscular exercise often grow fat, but the tendency to fatness or leanness is more or less a question of personal idiosyncrasy or some other little understood factor, and not decided by food and exercise alone.

CARBOHYDRATES.

These include such compounds as starches, different kinds of sugar, and the fiber of plants or cellulose. They are found chiefly in the vegetable foods, like cereal grains and potatoes; milk, however, contains considerable amounts of milk sugar, which is a carbohydrate. The carbohydrates form only a very small proportion of the body tissues—less than 1 per cent. Starches and sugars, which are very abundant in ordinary food materials, are important food ingredients, because they form an abundant source of energy and are easily digested. They may be and often are transformed into fat in the body.

REFUSE.

Food, as we buy it at the market or even as it is served on the table, contains more or less of materials which we can not or do not eat, and which would have little or no nutritive value if we did eat them; such, for instance, as the bones of meat and fish, the shells of eggs, and the skins and seeds of fruits and vegetables. In discussing the chemical composition of foods such portions are usually counted as refuse, but they make an important item when we consider the actual cost of the nutrients of food. The materials grouped together as refuse contain, in part, the same ingredients as the edible portion, though usually in very different proportions. Thus bones are largely mineral matter, with some fat and protein; eggshells are almost entirely mineral matter; bran of wheat has a high content of fiber or woody material. Generally speaking, vegetable refuse is characterized by a high content of these latter constituents. In some cases material which is edible is classed as refuse because the flavor is objectionable. Thus peach and plum pits are too highly flavored to be agreeable if eaten in quantity, and are commonly thought to be actually injurious.

FOOD AS BUILDING MATERIAL AND FUEL.

THE BODY AS A MACHINE.

Blood and muscle, bone and tendon, brain and nerve—all the organs and tissues of the body—are built from the nutritive ingredients of food. With every motion of the body and with the exercise of feeling and thought as well, material is consumed and must be resupplied by food. In a sense, the body is a superior machine. Like other machines, it requires material to build up its several parts, to repair them as they are worn out, and to serve as fuel. In some ways it uses this material like a machine; in others it does not. The steam engine gets its power from fuel; the body does the same. In the one case coal or wood, in the other food, is the fuel. In both cases the energy which is latent in the fuel—the potential energy, as it is called in scientific language—is transformed into power and heat.

From the time foods are taken into the body until they are digested, absorbed, utilized, and finally converted largely into the carbon dioxid and water vapor of the breath and the nitrogenous and other excretory products of the urine and feces, they undergo great chemical changes, very many of which liberate heat as a result of oxidation or some closely related process. It is through these complex chemical processes that the body derives the energy for internal and external muscular work. Heat is evolved by such chemical changes and also results from the muscular work of the body, and there is reason to believe that within wide limits the heat thus produced is sufficient for maintaining body temperature. The amount of heat produced in the body

must, of course, vary with the amount of food eaten, the work done, and other circumstances. However, the body is such a perfect piece of mechanism that the loss of heat by radiation, etc., is so adjusted to heat production that body temperature remains fairly constant.

One important difference between the human machine and the steam engine is that the former is self-building, self-repairing, and self-regulating. Another is that the material of which the engine is built is very different from that which it uses for fuel, but part of the material which serves the body as a source of energy also builds it up and keeps it in repair. Furthermore, the body can use its own substance for this purpose. This the steam engine can not do. The steam engine and the body are alike in that both convert the fuel into mechanical power and heat. They differ in that the body uses the same material for fuel as for building and also consumes its own material for fuel. In the use of its source of power the body is much more economical than any engine.

But the body is more than a machine. It has not simply organs to build and keep in repair and supply with energy; it has a nervous organization; it has sensibilities; and there are the higher intellectual and spiritual faculties. The right exercise of these depends upon the right nutrition of the body.

The chief uses of food, then, are two: (1) To form the material of the body and repair its wastes, and (2) to furnish muscular and other power for the work the body has to do and yield heat to keep the body warm. In forming the tissues and the fluids of the body the food serves for building and repair. In yielding power and heat it serves as fuel.

If more food is eaten than is needed, more or less of the surplus may be and sometimes is stored in the body, chiefly in the form of fat. The fat in the body forms a sort of reserve supply of fuel and is utilized in the place of food. When the work is hard or the food supply is low the body draws upon this store of fat and grows lean.

PROTEIN AS BUILDING MATERIAL.

The principal tissue formers are the protein compounds, especially the albuminoids. These make the framework of the body. They build up and repair the nitrogeneous materials, as the muscles and tendons, and supply the albuminoids of the blood, milk, and other fluids.

The albuminoids of food are transformed into the albuminoids and gelatinoids of the body. Muscle, tendon and cartilage, bone and skin, the corpuscles of the blood, and the casein of milk are made of the albuminoids of food. The albuminoids are sometimes called "flesh formers" or "muscle formers," because the lean flesh, the muscle, is made from them, though the term is inadequate, as it leaves out of account the energy-furnishing function of protein. The gelatinoids of food, such as the finer particles of tendon and the gelatin, which are

dissolved out of bone and meat in soup, though somewhat similar to the albuminoids in composition, are not believed to be tissue formers; but they are valuable in protecting the albuminoids from consumption. That is, when the food contains gelatinoids in abundance less of albuminoids is used.

The proteids can be so changed in the body as to yield fats and carbohydrates, and such changes actually occur to some extent. In this and other ways they supply the body with fuel.

PROTEIN AS FUEL FOR THE BODY.

The protein compounds are not only used for building and repairing tissue, but are also burned directly in the body like the carbohydrates, and thus render important service as fuel. A dog can live on lean meat. He can convert its material into muscle and its energy into heat and muscular power. Man can do the same; but such a one-sided diet would not be best for the dog and it would be still worse for man. The natural food for carniverous animals, like the dog, supplies fats and some carbohydrates, and that for omnivorous animals, like man, furnishes fats and carbohydrates in liberal amounts along with protein. Herbivorous animals, like horses, cattle, and sheep, naturally require large proportions of carbohydrates.

FATS AND CARBOHYDRATES AS FUEL.

Fats and carbohydrates are the chief fuel ingredients of food. Sugar and the starch of bread and potatoes are burned in the body to yield heat and power. The fats, such as the fat of meat and butter, serve the same purpose, only they are a more concentrated fuel than the carbohydrates.

The body can also transform carbohydrates of food into fat. This fat, and with it that stored from the food, is kept in the body as reserve fuel in the most concentrated form.

The different nutrients can to a greater or less extent do one another's work. If the body has not enough of one kind of fuel it can use another. But, while protein can be burned in the place of fats and carbohydrates, neither of the latter can take the place of the albuminoids in building and repairing the tissues. At the same time the gelatinoids, fats, and carbohydrates, by being consumed themselves, protect the albuminoids from consumption.

VALUE OF FOOD FOR SUPPLYING ENERGY.

Heat and muscular power are forms of force or energy. The energy latent in the food is developed as the food is consumed in the body. The process is more or less akin to that which takes place when coal is burned in the furnace of the locomotive. For the burning of the food in the body or the coal in the furnace, air is used to supply oxygen.

When the fuel is oxidized, be it meat or wood, bread or coal, the latent energy becomes active, or, in technical language, the potential energy becomes kinetic; it is transformed into power and heat. As various kinds of coal differ in the amount of heat given off per ton, so various kinds of food and food ingredients give off different amounts of energy; that is, have different values as fuel in the body.

HEAT OF COMBUSTION.

The processes of oxidation of material and transformation of energy in the body are less simple than in the engine and less clearly understood. Late research, however, has given us ways of measuring the energy latent in coal, wood, and in food materials as well. This is most generally done in the chemical laboratory by an apparatus called the bomb calorimeter. The amount of heat given off in the oxidation oi a given quantity of any material is called its "heat of combustion," and is taken as a measure of its latent or potential energy. The unit commonly used is the calorie, the amount of heat which would raise the temperature of 1 kilogram of water 1° C., or, what is nearly the same thing, 1 pound of water 4° F. Instead of this unit of heat a unit of mechanical energy may be used—for instance, the foot-ton, which represents the force required to raise 1 ton 1 foot. One calorie is equal to very nearly 1.54 foot-tons; that is to say, 1 calorie of heat, when transformed into mechanical power, would suffice to lift 1 ton 1.54 feet.

THE CONSERVATION OF ENERGY IN THE BODY.

The amounts of energy transformed in the body when food and its own material are burned within it are measured with the respiration calorimeter referred to on page 13. It is well known that the food is not completely oxidized in the body. These experiments have shown that the material which is oxidized yields the same amount of energy as it would if burned with oxygen outside the body, e. g., in the bomb calorimeter. The experiments show also that when a man does no muscular work (save, of course, the internal work of respiration, circulation, etc.), all the energy leaves his body as heat; but when he does muscular work, as in lifting weights or driving a bicycle, part of the energy appears in the external work thus done, and the rest is given off from the body as heat. The most interesting result of all is that the energy given off from the body as heat when the man is at rest, or as heat and mechanical work together when he is working, exactly equals the latent energy of the material burned in the body. This is in accordance with the law of the conservation of energy. It thus appears that the body actually obeys, as we should expect it to obey, this great law which dominates the physical universe.

FUEL VALUE.

We may make practical application of this principle of the conservation of energy in the body in measuring the actual value of food as fuel to the body, i. e., its "fuel value," by use of the bomb and respiration calorimeters. To do this we have to take into account the chemical composition of the food, the proportions of the nutrients actually digested and oxidized in the body, and the proportion of the whole latent energy of each which becomes active and useful to the body for warmth and work. Taking our common food materials as they are used in ordinary diet, the following general estimate has been made for the energy furnished to the body by 1 gram or 1 pound of each of the classes of nutrients:[a]

Protein, fuel value, 4 calories per gram, or 1,820 calories per pound.
Fats, fuel value, 9 calories per gram, or 4,040 calories per pound.
Carbohydrates, fuel value, 4 calories per gram, or 1,820 calories per pound.

It will be seen that when we compare the nutrients in respect to their fuel value, their capacities for yielding heat and mechanical power, a pound of protein of lean meat or albumen of egg is just about equivalent to a pound of sugar or starch, and a little over 2 pounds of either would be required to equal a pound of the fat of meat or butter or of body fat.

The fuel value of food obviously depends upon the amounts of actual nutrients, and especially upon the amount of fat it contains. Thus a pound of wheat flour, which consists largely of starch, has an average fuel value of about 1,625 calories, and a pound of butter, which is mostly fat, about 3,410 calories. These are only about one-eighth water. Whole milk, which is seven-eighths water, has an average fuel value of 310 calories per pound; cream, which has more fat and less water, 865 calories, and skim milk, which is whole milk after the cream has been removed, 165 calories.

This high fuel value of fat explains the economy of nature in storing fat in the body for use in case of need. Fat is the most concentrated form of body fuel.

We have been considering food as a source of heat and muscular power. There is no doubt that intellectual activity, also, is somehow dependent upon the consumption of material which the brain has obtained from the food; but just what substances are consumed to produce brain and nerve force, and how much of each is required for a given quantity of intellectual labor, are questions which the physiological chemist has not yet answered.

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[a] These estimates are based upon the latest and most reliable research and take into account only the material which is digested and oxidized so that its energy is actually available to the body. Earlier estimates, based on less accurate data and not making allowance for the amounts of fats and carbohydrates which escape oxidation in the body, give 4.1 calories per gram, or 1,860 calories per pound, for protein and carbohydrates and 9.3 calories per gram, or 4,220 for fats, figures which have come into common use.

HOW THE FUNCTIONS AND NUTRITIVE VALUE OF FOOD ARE LEARNED.

The principles above explained are based upon a great deal of experimenting and observation. The experimenting is of many kinds, but of especial importance is the work with the respiration apparatus and respiration calorimeter.

Various forms of respiration apparatus have been devised within the last fifty years. Among the most important are those invented by Pettenkofer and Voit in Munich. They consist of metal-walled chambers large enough for the subject (sometimes a man, sometimes a dog, sheep, or other animal) to live in comfortably for several days, and are furnished with devices for pumping air through and measuring and analyzing it as it enters and leaves the chamber. With such an apparatus it is possible not only to measure all the food and excreta, but also the materials given off from the lungs in the breath, and to make accurate determinations of the matter entering and leaving the body.

A still more elaborate apparatus, by which not only all the matter passing in and out of the body may be measured, but also all the heat given off from it, is called a respiration calorimeter—that is, a machine for measuring both the respiratory products and the heat given off by the body. It is like the respiration apparatus, except that it is furnished with devices for measuring temperatures. Several have been built in Europe within the last twenty years, among the most successful being those by Rubner and Rosenthal.[a] Investigations in cooperation with the United States Department of Agriculture are now being carried on in one recently built by the author and Professor Rosa at Wesleyan University.[b] Its main feature is a copper-walled chamber 7 feet long, 4 feet wide, and 6 feet 4 inches high. This is fitted with devices for maintaining and measuring a ventilating current of air, for sampling and analyzing this air, for removing and measuring the heat given off within the chamber, and for passing food and other articles in and out. It is furnished with a folding bed, chair, and table, with scales and with appliances for muscular work, and has telephone connection with the outside. Here the subject stays for a period of from three to twelve days, during which time careful analyses and measurements are made of all material which enters the body in the food and of that which leaves it in the breath and excreta. Record is also kept of the energy given off from the body as heat and muscular work. The differences between the material taken into and that given off from the body is called the balance of matter, and shows whether the body is gaining or losing material. The dif-

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 133.

[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 63.

ference between the energy of the food taken and that of the excreta and the energy given off from the body as heat and muscular work, is the balance of energy, and if correctly estimated should equal the energy of the body material gained or lost.

With such apparatus it is possible to learn what effect different conditions of nourishment will have on the human body. In one experiment, for instance, the subject might be kept quite at rest, and in the next do a certain amount of muscular or mental work, with the same diet as before. Then by comparing the results of the two the use which the body makes of its food under the different conditions could be determined. Or the diet may be slightly changed in one experiment and the effect of this on the balance of matter and energy observed. Such methods and apparatus are very costly in time and money, but the results are proportionately more valuable than those from simpler experiments.

FOOD AND FOOD ECONOMY.

What has thus far been said about the ingredients of food and the ways they are used in the body may be briefly summarized in the following schematic manner:

Nutritive ingredients (or nutrients) of food.

Food as purchased contains—
- Edible portion.......................
  e. g., flesh of meat, yolk and white of eggs, wheat, flour, etc.
  - Water.
  - Nutrients...
    - Protein.
    - Fats.
    - Carbohydrates.
    - Mineral matters.
- Refuse.
  e. g., bones, entrails, shells, bran, etc.

Uses of nutrients in the body.

Protein...................... e. g., white (albumen) of eggs, curd (casein) of milk, lean meat, gluten of wheat, etc.	Forms tissue..................	All serve as fuel to yield energy in the forms of heat and muscular power.
Fats......................... e. g., fat of meat, butter, olive oil, oils of corn and wheat, etc.	Are stored as fat..............	
Carbohydrates................ e. g., sugar, starch, etc.	Are transformed into fat.......	
Mineral matters (ash)........ e. g., phosphates of lime, potash, soda, etc.	Share in forming bone, assist in digestion, etc.	

The views thus presented lead to the following definitions: (1) Food is that which, taken into the body, builds tissues or yields energy;

(2) the most healthful food is that which is best fitted to the needs of the user; (3) the cheapest food is that which furnishes the largest amount of nutriment at the least cost; and (4) the best food is that which is both most healthful and cheapest.

We have, then, to consider the kinds and amounts of nutrients in different food materials, their digestibility, the kinds and amounts needed for nourishment by persons under different conditions of rest and work, and the nutritive value of different food products as compared with their cost.

COMPOSITION OF COMMON FOOD MATERIALS.

The value of food for nutriment depends mainly upon its composition and digestibility. The composition of foods is determined by chemical analysis. The first effective impulse to the systematic study of the chemistry of foods was given by Liebig somewhat over 50 years ago, but nearly all of our definite knowledge of the chemical composition of food materials has accumulated within comparatively a few years past.

Until about the year 1880 those who wished to know about the chemical composition of food materials were compelled to depend upon analyses of European products, and most of those analyses had been made in German laboratories. During the last two decades, however, American investigations have accumulated until at the present time the results of over 4,000 analyses of food materials from different parts of the United States are available. A large proportion of these analyses have been made during the last few years in connection with nutrition investigations under the auspices of the Department of Agriculture.

The methods of chemical analysis of foods are now so nearly uniform throughout the world that the analyses reported from different countries furnish a reliable means of comparing the composition of the food products of different parts of the world.

Table I shows the average composition of ordinary American food materials as calculated from the analyses now available.[a] The value of food as influenced by digestibility is discussed later. (See Table II, p. 27.)

[a]Condensed from U. S. Dept. Agr., Office of Experiment Stations Bul. 28, revised.

TABLE I.—*Average composition of common American food products.*

Food materials (as purchased).	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD.							
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Beef, fresh:							
Chuck ribs	16.3	52.6	15.5	15.0		0.8	910
Flank	10.2	54.0	17.0	19.0		.7	1,105
Loin	13.3	52.5	16.1	17.5		.9	1,025
Porterhouse steak	12.7	52.4	19.1	17.9		.8	1,100
Sirloin steak	12.8	54.0	16.5	16.1		.9	975
Neck	27.6	45.9	14.5	11.9		.7	1,165
Ribs	20.8	43.8	13.9	21.2		.7	1,135
Rib rolls		63.9	19.3	16.7		.9	1,055
Round	7.2	60.7	19.0	12.8		1.0	890
Rump	20.7	45.0	13.8	20.2		.7	1,090
Shank, fore	36.9	42.9	12.8	7.3		.6	545
Shoulder and clod	16.4	56.8	16.4	9.8		.9	715
Fore quarter	18.7	49.1	14.5	17.5		.7	995
Hind quarter	15.7	50.4	15.4	18.3		.7	1,045
Beef, corned, canned, pickled, and dried:							
Corned beef	8.4	49.2	14.3	23.8		4.6	1,245
Tongue, pickled	6.0	58.9	11.9	19.2		4.3	1,010
Dried, salted, and smoked	4.7	53.7	26.4	6.9		8.9	790
Canned boiled beef		51.8	25.5	22.5		1.3	1,410
Canned corned beef		51.8	26.3	18.7		4.0	1,270
Veal:							
Breast	21.3	52.0	15.4	11.0		.8	745
Leg	14.2	60.1	15.5	7.9		.9	625
Leg cutlets	3.4	68.3	20.1	7.5		1.0	695
Fore quarter	24.5	54.2	15.1	6.0		.7	535
Hind quarter	20.7	56.2	16.2	6.6		.8	580
Mutton:							
Flank	9.9	39.0	13.8	36.9		.6	1,770
Leg, hind	18.4	51.2	15.1	14.7		.8	890
Loin chops	16.0	42.0	13.5	28.3		.7	1,415
Fore quarter	21.2	41.6	12.3	24.5		.7	1,235
Hind quarter, without tallow	17.2	45.4	13.8	23.2		.7	1,210
Lamb:							
Breast	19.1	45.5	15.4	19.1		.8	1,075
Leg, hind	17.4	52.9	15.9	13.6		.9	860
Pork, fresh:							
Ham	10.7	48.0	13.5	25.9		.8	1,320
Loin chops	19.7	41.8	13.4	24.2		.8	1,245
Shoulder	12.4	44.9	12.0	29.8		.7	1,450
Tenderloin		66.5	18.9	13.0		1.0	895
Pork, salted, cured, and pickled:							
Ham, smoked	13.6	34.8	14.2	33.4		4.2	1,635
Shoulder, smoked	18.2	36.8	13.0	26.6		5.5	1,335
Salt pork		7.9	1.9	86.2		3.9	3,555
Bacon, smoked	7.7	17.4	9.1	62.2		4.1	2,715
Sausage:							
Bologna	3.3	55.2	18.2	19.7		3.8	1,155
Pork		39.8	13.0	44.2	1.1	2.2	2,075
Frankfort		57.2	19.6	18.6	1.1	3.4	1,155
Soups:							
Celery, cream of		88.6	2.1	2.8	5.0	1.5	235
Beef		92.9	4.4	.4	1.1	1.2	120
Meat stew		84.5	4.6	4.3	5.5	1.1	365
Tomato		90.0	1.8	1.1	5.6	1.5	185
Poultry:							
Chicken, broilers	41.6	43.7	12.8	1.4		.7	305
Fowls	25.9	47.1	13.7	12.3		.7	765
Goose	17.6	38.5	13.4	29.8		.7	1,475
Turkey	22.7	42.4	16.1	18.4		.8	1,060
Fish:							
Cod, dressed	29.9	58.5	11.1	.2		.8	220
Halibut, steaks or sections	17.7	61.9	15.3	4.4		.9	475
Mackerel, whole	44.7	40.4	10.2	4.2		.7	370
Perch, yellow, dressed	35.1	50.7	12.8	.7		.9	275
Shad, whole	50.1	35.2	9.4	4.8		.7	380
Shad, roe		71.2	20.9	3.8	2.6	1.5	600
Fish, preserved:							
Cod, salt	24.9	40.2	16.0	.4		18.5	325
Herring, smoked	44.4	19.2	20.5	8.8		7.4	755
Fish, canned:							
Salmon		63.5	21.8	12.1		2.6	915
Sardines	[a] 5.0	53.6	23.7	12.1		5.3	950
Shellfish:							
Oysters, "solids"		88.3	6.0	1.3	3.3	1.1	225
Clams		80.8	10.6	1.1	5.2	2.3	340
Crabs	52.4	36.7	7.9	.9	.6	1.5	200
Lobsters	61.7	30.7	5.9	.7	.2	.8	145

[a] Refuse, oil.

TABLE I.—*Average composition of common American food products*—Continued.

Food materials (as purchased).	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD—continued.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Eggs: Hens' eggs	[a] 11.2	65.5	13.1	9.3	....	0.9	635
Dairy products, etc.:							
Butter	....	11.0	1.0	85.0	....	3.0	3,410
Whole milk	....	87.0	3.3	4.0	5.0	.7	310
Skim milk	....	90.5	3.4	.3	5.1	.7	165
Buttermilk	....	91.0	3.0	.5	4.8	.7	160
Condensed milk	....	26.9	8.8	8.3	54.1	1.9	1,430
Cream	....	74.0	2.5	18.5	4.5	.5	865
Cheese, Cheddar	....	27.4	27.7	36.8	4.1	4.0	2,075
Cheese, full cream	....	34.2	25.9	33.7	2.4	3.8	1,885
VEGETABLE FOOD.							
Flour, meal, etc.:							
Entire-wheat flour	....	11.4	13.8	1.9	71.9	1.0	1,650
Graham flour	....	11.3	13.3	2.2	71.4	1.8	1,645
Wheat flour, patent roller process—							
High-grade and medium	....	12.0	11.4	1.0	75.1	.5	1,635
Low grade	....	12.0	14.0	1.9	71.2	.9	1,640
Macaroni, vermicelli, etc	....	10.3	13.4	.9	74.1	1.3	1,645
Wheat breakfast food	....	9.6	12.1	1.8	75.2	1.3	1,680
Buckwheat flour	....	13.6	6.4	1.2	77.9	.9	1,605
Rye flour	....	12.9	6.8	.9	78.7	.7	1,620
Corn meal	....	12.5	9.2	1.9	75.4	1.0	1,635
Oat breakfast food	....	7.7	16.7	7.3	66.2	2.1	1,800
Rice	....	12.3	8.0	.3	79.0	.4	1,620
Tapioca	....	11.4	.4	.1	88.0	.1	1,650
Starch	....	....	....	....	90.0	....	1,675
Bread, pastry, etc.:							
White bread	....	35.3	9.2	1.3	53.1	1.1	1,200
Brown bread	....	43.6	5.4	1.8	47.1	2.1	1,040
Graham bread	....	35.7	8.9	1.8	52.1	1.5	1,195
Whole-wheat bread	....	38.4	9.7	.9	49.7	1.3	1,130
Rye bread	....	35.7	9.0	.6	53.2	1.5	1,170
Cake	....	19.9	6.3	9.0	63.3	1.5	1,630
Cream crackers	....	6.8	9.7	12.1	69.7	1.7	1,925
Oyster crackers	....	4.8	11.3	10.5	70.5	2.9	1,910
Soda crackers	....	5.9	9.8	9.1	73.1	2.1	1,875
Sugars, etc.:							
Molasses	....	....	....	....	70.0	....	1,225
Candy [b]	....	....	....	....	96.0	....	1,680
Honey	....	....	....	....	81.0	....	1,420
Sugar, granulated	....	....	....	....	100.0	....	1,750
Maple sirup	....	....	....	....	71.4	....	1,250
Vegetables: [c]							
Beans, dried	....	12.6	22.5	1.8	59.6	3.5	1,520
Beans, Lima, shelled	....	68.5	7.1	.7	22.0	1.7	540
Beans, string	7.0	83.0	2.1	.3	6.9	.7	170
Beets	20.0	70.0	1.3	.1	7.7	.9	160
Cabbage	15.0	77.7	1.4	.2	4.8	.9	115
Celery	20.0	75.6	.9	.1	2.6	.8	65
Corn, green (sweet), edible portion	....	75.4	3.1	1.1	19.7	.7	440
Cucumbers	15.0	81.1	.7	.2	2.6	.4	65
Lettuce	15.0	80.5	1.0	.2	2.5	.8	65
Mushrooms	....	88.1	3.5	.4	6.8	1.2	185
Onions	10.0	78.9	1.4	.3	8.9	.5	190
Parsnips	20.0	66.4	1.3	.4	10.8	1.1	230
Peas (*Pisum sativum*), dried	....	9.5	24.6	1.0	62.0	2.9	1,565
Peas (*Pisum sativum*), shelled	....	74.6	7.0	.5	16.9	1.0	440
Cowpeas, dried	....	13.0	21.4	1.4	60.8	3.4	1,505
Potatoes	20.0	62.6	1.8	.1	14.7	.8	295
Rhubarb	40.0	56.6	.4	.4	2.2	.4	60
Sweet potatoes	20.0	55.2	1.4	.6	21.9	.9	440
Spinach	....	92.3	2.1	.3	3.2	2.1	95
Squash	50.0	44.2	.7	.2	4.5	.4	100
Tomatoes	....	94.3	.9	.4	3.9	.5	100
Turnips	30.0	62.7	.9	.1	5.7	.6	120
Vegetables, canned:							
Baked beans	....	68.9	6.9	2.5	19.6	2.1	555
Peas (*Pisum sativum*), green	....	85.3	3.6	.2	9.8	1.1	235
Corn, green	....	76.1	2.8	1.2	19.0	.9	430
Succotash	....	75.9	3.6	1.0	18.6	.9	425
Tomatoes	....	94.0	1.2	.2	4.0	.6	95

[a] Refuse, shell.
[b] Plain confectionery not containing nuts, fruit, or chocolate.
[c] Such vegetables as potatoes, squash, beets, etc., have a certain amount of inedible material, skin, seeds, etc. The amount varies with the method of preparing the vegetables, and can not be accurately estimated. The figures given for refuse of vegetables, fruits, etc., are assumed to represent approximately the amount of refuse in these foods as ordinarily prepared.

TABLE I.—*Average composition of common American food products*—Continued.

Food materials (as purchased).	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound
VEGETABLE FOOD—continued.							
Fruits, berries, etc., fresh: [a]	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Apples	25.0	63.3	0.3	0.3	10.8	0.3	190
Bananas	35.0	48.9	.8	.4	14.3	.6	260
Grapes	25.0	58.0	1.0	1.2	14.4	.4	295
Lemons	30.0	62.5	.7	.5	5.9	.4	125
Muskmelons	50.0	44.8	.3	....	4.6	.3	80
Oranges	27.0	63.4	.6	.1	8.5	.4	150
Pears	10.0	76.0	.5	.4	12.7	.4	230
Persimmons, edible portion	....	66.1	.8	.7	31.5	.9	550
Raspberries	....	85.8	1.0	....	12.6	.6	220
Strawberries	5.0	85.9	.9	.6	7.0	.6	150
Watermelons	59.4	37.5	.2	.1	2.7	.1	50
Fruits, dried:							
Apples	....	28.1	1.6	2.2	66.1	2.0	1,185
Apricots	....	29.4	4.7	1.0	62.5	2.4	1,125
Dates	10.0	13.8	1.9	2.5	70.6	1.2	1,275
Figs	....	18.8	4.3	.3	74.2	2.4	1,280
Raisins	10.0	13.1	2.3	3.0	68.5	3.1	1,265
Nuts:							
Almonds	45.0	2.7	11.5	30.2	9.5	1.1	1,515
Brazil nuts	49.6	2.6	8.6	33.7	3.5	2.0	1,485
Butternuts	86.4	.6	3.8	8.3	.5	.4	385
Chestnuts, fresh	16.0	37.8	5.2	4.5	35.4	1.1	915
Chestnuts, dried	24.0	4.5	8.1	5.3	56.4	1.7	1,385
Cocoanuts	[b] 48.8	7.2	2.9	25.9	14.3	.9	1,295
Cocoanut, prepared	....	3.5	6.3	57.4	31.5	1.3	2,865
Filberts	52.1	1.8	7.5	31.3	6.2	1.1	1,430
Hickory nuts	62.2	1.4	5.8	25.5	4.3	.8	1,145
Pecans, polished	53.2	1.4	5.2	33.3	6.2	.7	1,465
Peanuts	24.5	6.9	19.5	29.1	18.5	1.5	1,775
Piñon (*Pinus edulis*)	40.6	2.0	8.7	36.8	10.2	1.7	1,730
Walnuts, black	74.1	.6	7.2	14.6	3.0	.5	730
Walnuts, English	58.1	1.0	6.9	26.6	6.8	.6	1,250
Miscellaneous:							
Chocolate	....	5.9	12.9	48.7	30.3	2.2	5,625
Cocoa, powdered	....	4.6	21.6	28.9	37.7	7.2	2,160
Cereal coffee, infusion (1 part boiled in 20 parts water) [c]	....	98.2	.2	....	1.4	.2	30

[a] Fruits contain a certain proportion of inedible materials, as skin, seeds, etc., which are properly classed as refuse. In some fruits, as oranges and prunes, the amount rejected in eating is practically the same as refuse. In others, as apples and pears, more or less of the edible material is ordinarily rejected with the skin and seeds and other inedible portions. The edible material which is thus thrown away, and should properly be classed with the waste, is here classed with the refuse. The figures for refuse here given represent, as nearly as can be ascertained, the quantities ordinarily rejected.

[b] Milk and shell.

[c] The average of five analyses of cereal coffee grain is: Water 6.2, protein 13.3, fat 3.4, carbohydrates 72.6, and ash 4.5 per cent. Only a portion of the nutrients, however, enter into the infusion. The average in the table represents the available nutrients in the beverage. Infusions of genuine coffee and of tea like the above contain practically no nutrients.

PROPORTIONS OF NONNUTRIENTS IN FOODS.

It will be interesting to note some of the differences in food materials as shown by their composition. One of the first things which may be observed when a table like the above is studied, is the differences in the proportions of nonnutrients, i. e., refuse and water. Many kinds of food as they are purchased contain large amounts of refuse, as the skin and bones of meat and fish, the skin or rind and seeds of vegetables, etc., which necessarily lessen the proportion of nutrients. While such refuse is found in meats, fish, eggs, fresh vegetables, and fruits, it is usually absent in the dairy products (milk, butter, cheese, etc.), dried vegetables, cereal foods (flour, breakfast foods, etc.), and the bread, cakes, and other foods prepared from them. In considering the edible portion we find that the amount of water present

also affects the nutritive value of food. Water is necessary to the body, and it is usually supplied in abundance by beverages, although the amount contained in the solid food consumed in a day is quite considerable. Water forms from 40 to 50 per cent of the ordinary cuts of meat; it is especially abundant in the flesh of lean animals, and tends to decrease as fat increases, and vice versa. It is even more abundant in fresh fish than in meats, but in dried fish there is of course comparatively little. Fresh vegetables and fruits contain sometimes as much as 80 or 90 per cent or more of water, while dried seeds and the food materials prepared from them (beans, peas, meals, flour, cereal breakfast foods, etc.) usually contain, roughly speaking, from 10 to 12 per cent of water. Many cooked foods contain more water than the raw materials from which they are made, owing to the quantities added in cooking. Thus some thin soups are little more than flavored and colored water, and of course have an extremely low nutritive value. In other cooked foods, notably meat, which have been baked, roasted, or fried, the amount of water is diminished by cooking.

PROPORTIONS OF NUTRIENTS IN FOODS.

The most important of the actual nutrients has been seen to be protein. This occurs most abundantly in animal foods—meat, fish, eggs, and dairy products, and in the dried legumes, as beans and peas. Butter and lard are exceptions to this statement, as they represent the fat of milk and meat. The proportion of protein present in meats and fish varies greatly with the kind and cut. In beef, veal, and mutton it composes between 14 and 26 per cent of the edible portion. It is generally less abundant in the flesh of fish, because the latter is more watery than meat. The fatter the meat the smaller is the proportion of protein; lean pork has less than beef and mutton, and fat pork almost none. It is more abundant in cheese (28–38 per cent) and likewise in dried beans and peas (18–25 per cent). Protein makes up, roughly speaking, from 7 to 15 per cent of the cereals, being least abundant in rye and buckwheat and most abundant in oats. Wheat flour averages not far from 11 per cent and bread not far from 9 per cent of protein. Fresh vegetables and fruits contain almost no protein, seldom if ever more than 5 and often only 1 per cent or less.

The chief sources of fat in ordinary diet are the animal foods, though some fat is derived from vegetable foods. The quantities present in meats vary considerably, ranging from less than 10 per cent in some cuts of beef and veal to over 40 per cent in a side of pork and over 80 per cent in fat salt pork. The leaner fish, like cod and haddock, usually contain almost none, but in the fatter kind, like shad, mackerel, and notably salmon, there is often from 5 to 10 per cent and sometimes as much as 15 per cent of fat. The chemical composition of

salmon is not unlike that of lean meat. In both meat and fish the increase of fat usually means a decrease in the proportion of water, as was stated above. Milk averages about 4 per cent of fat. Butter is, as we have seen, nearly pure fat, and whole milk cheese may have anywhere from 25 to 40 per cent of fat, according to the richness of the cream or milk from which it is made.

The olive and the cotton seed are rich in fat, large quantities of them being used annually for the production of oils. Most of our common edible nuts also contain considerable fat. With the exception of oatmeal, which contains about 7 per cent, there is comparatively little fat in the cereals in the form in which they are ordinarily purchased, or in the dried legumes, while in the green vegetables and most fruits it is practically wanting.

The carbohydrates, unlike the fats, are almost entirely absent from the animal foods, except milk, but form the most important nutrient of most vegetable foods. Some glycogen (a carbohydrate) is found in the liver and in other animal tissues. The carbohydrates make up from 70 to 80 per cent of the cereals, 60 to 70 per cent of the dried legumes, and the bulk of the nutrients of fresh vegetables and fruits. The nutrients of sugar, molasses, honey, etc., are, of course, almost entirely carbohydrates.

Mineral matters occur in all the ordinary articles of food. Fresh meats and fish contain not far from 1 per cent, although in fat, unsalted pork the quantity may be as small as 0.1 per cent. Milk contains about 0.7 per cent mineral matters. In the cereals the proportion ranges from about 0.3 to over 2 per cent, while in green vegetables and fruits it is usually less than 1 per cent. The dried legumes contain from 3 to 4 per cent of mineral matters.

In brief, then, it may be said that meats, fish, eggs, milk, fresh vegetables, and fruits contain the most refuse and water; that protein is most abundant in the animal foods and in the legumes and occurs in considerable quantities in the cereals; that fats occur principally in the animal foods; that carbohydrates are found almost exclusively in the vegetable products and milk; and that small quantities of mineral matters are found in all food materials. The fuel value varies within wide limits, being greatest in those materials which contain the most fat and the least water.

DIGESTION, ASSIMILATION, AND EXCRETION.

"We live not upon what we eat, but upon what we digest." Food as we buy it in the market, or even as we eat it, is not usually in condition to be made into body structure or used as body fuel. It must first go through a series of chemical changes by what is called digestion, which prepare it to be absorbed, taken into the blood and lymph, and carried

to the parts of the body where it is needed. Digestion takes place in the alimentary canal, partly in the stomach, but more in the intestine. As the result, the useless portions are separated and rejected, while the parts which can serve for nutriment are changed into forms in which they can be absorbed, taken into the circulation, and utilized.

DIGESTION.

The alterations which the food undergoes in digestion are brought about by substances called ferments, which are secreted by the digestive organs. The saliva in the mouth has the power of changing insoluble starches into soluble sugar, but as the food stays in the mouth only a short time, there is generally little chance for such action. The saliva, however, helps to fit the food to be more easily worked on by the stomach. The gastric juice of the stomach acts upon protein, and the pancreatic juice of the intestine upon protein, fats, and carbohydrates. The action of all the ferments is aided by the fine division of the food by chewing and by the muscular contractions, the so-called peristaltic action, of the stomach and intestine. These latter motions help to mix the digestive juices and their ferments with the food.

The parts of the food which the digestive juices can not dissolve, and which therefore escape digestion, are periodically given off by the intestine. Such solid excreta, or feces, include not only the particles of undigested food, but also the so-called metabolic products, i. e., residues of the digestive juices, bits of the lining of the alimentary canal, etc.

ABSORPTION AND ASSIMILATION.

The digested food finds its way through the walls of the alimentary canal, and at this time and later it undergoes remarkable chemical changes. When finally the blood, supplied with the nutrients of the digested food and freighted with oxygen from the lungs, is pumped from the heart all over the body it is ready to furnish the organs and tissues with the materials and energy which they need for their peculiar functions; at the same time it carries away the waste which the exercise of these functions has produced. It is a characteristic of living body tissue that it can choose the necessary materials from the blood and build them into its own structure. How it does this is one of the mysteries of physiology. The body, as we have learned, has also the power of consuming not only the materials of the food, but also parts of its own structure for the production of muscular work, or heat, or to protect more important parts from consumption. How it does this is another mystery, still to be explained.

EXCRETION.

After the material has been thus assimilated and utilized the resulting waste products must be removed from the body. The chemical elements which this waste contains are of course the same as those making up the structure of the body and the food—carbon, oxygen, hydrogen, nitrogen, calcium, phosphorus, sulphur, etc. Most of the carbon and part of the oxygen are given off from the lungs as carbon dioxid. Hydrogen unites with more oxygen to form water, which is passed off in vapor from the lungs, in perspiration from the skin, and in urine from the kidneys. Almost all the nitrogen is excreted in the urine. Waste mineral matters are given off to some extent in the perspiration, but mainly through the kidneys and intestines.

APPARENT AND ACTUAL DIGESTIBILITY.

The real nutritive value of a food, then, depends not simply on the proportions of nutrients which it contains, but also on the amount of those nutrients which can be made available to the body by digestion for building material and for fuel. Part of the food eaten escapes digestion and is given off from the body in the feces. If we subtract the amount of this undigested residue from the total food, the remainder will be the amount actually digested in the stomach and intestines absorbed through their walls, and taken into the circulation. This difference between the amounts eaten and those undigested represents the actual digestibility of food. A part of the food taken into the circulation, however, is later returned again to the alimentary canal mainly in the digestive juices that are needed for digesting the food. The material thus removed from circulation and returned to the alimentary canal, which consists of so-called metabolic products, is excreted with the undigested residue in the feces. The remainder of the food taken into the circulation represents the amount retained by the body for building material and for fuel. The difference between the food which is absorbed and that which the body secures, therefore, is represented by the metabolic products. By the present methods of experimenting, however, the portion of the feces that consists of metabolic products can not be satisfactorily distinguished from the undigested residue. It is very difficult, therefore, to determine the actual digestibility, but comparatively easy to estimate the apparent digestibility of food.[a]

Suppose, for instance, that 15 per cent of the protein in a specimen of bread is excreted, then 85 per cent remains for the use of the body.

[a] It would be more exact to use different terms to denote the apparent digestibility of food as distinguished from its actual digestibility. It has therefore been proposed to limit the use of the term digestibility to actual digestibility and employ the term availability when apparent digestibility, as ordinarily determined in nutrition investigations, is meant. (See Connecticut Storrs Station Report 1899, p. 69.)

If the bread has 8.4 per cent of protein, 100 pounds will have 8.4 pounds, of which 85 per cent or 7.1 pounds will be utilized by the body. Table III (p. 28) gives details regarding the proportions of digestible nutrients in different food materials.

EASE AND QUICKNESS OF DIGESTION.

The terms digestible, indigestible, etc., as here used refer simply to the food which is or is not available for the general nourishment of the body after the process of digestion is completed. In common parlance, however, they are used more loosely as referring to the ease and quickness of digestion, and to the general healthfulness of food. One kind of food—bread, for instance—is spoken of as "simple" and "digestible," and another, like fruit cake, as "rich" and "indigestible." There is often much practical truth behind such statements, though little is definitely known concerning the time or labor required to digest different kinds of food.

Among the earliest and most famous experiments concerning the time required for digestion in the stomach are those made by Dr. William Beaumont, U. S. A., between 1825 and 1833. His subject was a French-Canadian trapper, a man quite normal except for an aperture through the abdomen into the stomach made by a gunshot wound, and closed only by a valve which had developed over it. By pressing the valve inward the contents of the stomach could be observed or removed at will, thus affording excellent opportunity to study the action of the gastric juice. Dr. Beaumont fed the man on various diets, and noted the different conditions accompanying each. The book in which he describes his experiments [a] contains a table of the average time required for the stomach to digest various articles of diet, from which many of the statements still current concerning the relative digestibility of different foods are taken.

One of Dr. Beaumont's general deductions was that most of the common foods required from 2 to 4 hours. He says further:

"The time required for the digestion of food is various, depending upon the quantity and quality of the food, state of the stomach, etc., but the time ordinarily required for the disposal of a moderate meal of the fibrous parts of meat, with bread, etc., is from 3 to 3½ hours."

Valuable and interesting as Dr. Beaumont's book undoubtedly is, its conclusions can not be taken as final, because he does not state the amounts of food consumed. The science of nutrition in its development has also shown many errors in the reasoning. It should in justice be said that Dr. Beaumont recognized the fact that his experiments had to do only with digestion in the stomach, or "chymifica-

[a] William Beaumont, The Physiology of Digestion, with Experiments on the Gastric Juice. 2d ed. Burlington, Vt., 1847.

tion," as he terms it. Furthermore, his experiments have been often misquoted and given a different interpretation from that which he intended.

Food does not ordinarily pass from the stomach into the intestine until it has been reduced to a liquid or semiliquid condition. The length of time required for different foods to leave the stomach has been recently studied by Penzoldt with healthy men. He used a stomach tube for removing the stomach contents for examination. He found that the amount and consistency of food have a marked influence on the rate of digestion in the stomach. Fluids leave the stomach more rapidly than other materials. From 6 to 7 ounces of water or other common beverages leave the stomach in 1½ hours. Seven ounces of boiled milk leave the stomach in about 2 hours. Hot drinks do not leave the stomach more quickly than cold ones, nor does the quantity have much effect. Solid matter in solution or suspension delayed the passage of fluid from the stomach somewhat. The consistency of solid foods thus seems to have more effect upon digestibility than the amount consumed. The quantity eaten increases the length of time the material remains in the stomach, but not proportionally.

To select a few examples of the time required for foods to leave the stomach: Two eggs (raw, poached, or in the form of an omelet), 7 ounces sweetbreads, 10 moderate-sized oysters, 7 ounces white-fish or 3½ ounces of white bread, cauliflowers, or cherries, each left the stomach in from 2 to 3 hours. Eight and one-fourth ounces of chicken, 9 ounces of lean beef, 6 ounces boiled ham, 3½ ounces roast veal or beefsteak, 5⅓ ounces of coarse bread, boiled rice, carrots, spinach, radish, or apple, left the stomach in 3 to 4 hours. Nine ounces of smoked tongue, 3½ ounces smoked beef, 9 ounces roast goose, 5⅓ ounces string beans, or 7 ounces peas porridge, left the stomach in 4 to 5 hours.

Generally speaking, the most readily digested animal foods were materials of soft consistency. White meats—for example, chicken—leave the stomach more quickly than red meats or dark meat—for instance, duck. The method of cooking also exerts a very marked influence on stomach digestion. Fresh fish was found to be more readily digested than meats.

As regards vegetable foods in general, the consistency and the amounts of solid material were again the principal factors affecting the time required for digestion in the stomach. Mealy potatoes, for instance, were more easily digested than waxy potatoes, and mashed potato more readily than potato cut up in pieces. Fine bread was more quickly digested than coarse bread. There was not much difference in the time required for bread crust, bread crumb, toast, new bread, and stale bread to digest in the stomach, provided all were equally well chewed.

It must be remembered that digestion continues in the intestine and that the total time required for the digestion and absorption of the nutrients in any given food material is not shown by such experiments. They find their chief application in prescribing a diet for invalids, as in such cases it is often desirable to require of the stomach only a limited amount of work.

AGREEMENT OF FOOD WITH INDIVIDUALS.

Digestibility is often confused with another very different thing, namely, the agreeing or disagreeing of food with the person who eats it. During the process of digestion and assimilation the food, as we have seen, undergoes many chemical changes, some of them in the intestines, some in the liver, muscles, and other organs. In these changes chemical compounds may be formed which are in one way or another unpleasant and injurious, especially if they are not broken down (as normally they are) before they have opportunity thus to act. Some of the compounds produced from the food in the body may be actually poisonous.

Different persons are differently constituted with respect to the chemical changes which their food undergoes and the effect produced, so that it may be literally true that "one man's meat is another man's poison." Milk is for most people a very wholesome, digestible, and nutritious food, but there are persons who are made ill by drinking it, and they should avoid milk. The writer knows a boy who is made seriously ill by eating eggs. A small piece of sweet cake in which eggs have been used will cause him serious trouble. The sickness is nature's evidence that eggs are for him an unfit article of food. Some persons have to avoid strawberries. Indeed, cases in which the most wholesome kinds of food are hurtful to individual persons are, unfortunately, numerous. Every man must learn from his own experience what food agrees with him and what does not.

How much harm is done by the injurious compounds sometimes formed from ordinary wholesome foods is seldom realized. Physiological chemistry is revealing the fact that these compounds may affect even the brain and nerves, and that some forms of insanity are caused by products formed by the abnormal transformations of food and body material.

PROPORTIONS OF DIGESTIBLE NUTRIENTS IN FOOD MATERIALS.

During the past few years many experiments have been made to test the proportions of nutrients digested from ordinary food materials. In making the experiments the subjects are kept on a simple diet, all the food and solid excreta are analyzed, and the difference between the two is taken to represent the amount of food which the

body secures for nutriment. Most of the subjects have been people in good health; the great majority have been men, but a few women, and especially children.

From comparison of the results of many such experiments much interesting knowledge has been gained of the relative digestibility of different kinds and classes of foods.

In general it may be said that probably most foods used by man are more completely digested than is ordinarily supposed, so that the bulk of the intestinal excretion is made up of metabolic products. Some foods, however, contain large proportions of material upon which the digestive juices can not so act as to make them capable of being absorbed. Thus the outer hull of the wheat grain contains woody substance which passes through the alimentary canal of man undigested, though animals, like cows and sheep, can digest a large part of it.

It has been found that in the total food of an ordinary mixed diet, on the average, about 92 per cent of the protein, 95 per cent of the fats, and 97 per cent of the carbohydrates are retained by the body. In the average proportions in which the different animal and vegetable foods are combined in the diet about 97 per cent of the protein, 95 per cent of the fats, and 98 per cent of the carbohydrates of the animal foods are digested, while only 84 per cent of the protein, 90 per cent of the fats, and 97 per cent of the carbohydrates of the vegetable foods are digested. Animal foods, therefore, seem to have a greater digestibility than vegetable, especially as regards the protein they contain. The digestibility of a given article of food depends, of course, upon the digestibility of the different classes of nutrients and upon the relative proportion in which these nutrients occur. Thus, of two cereals containing about the same amount of dry matter, but with different proportions of protein and carbohydrates, the one with the larger proportion of the less digestible protein and the smaller proportion of the more digestible carbohydrates will be, on the whole, less completely digested.

The figures given in Table I (p. 16) do not, then, represent the nutrients actually available for the uses of the body, but those contained in the food before it is eaten. The nutrients actually available must be calculated from the total amounts shown in the table by use of the proper factors for digestibility. Thus if 53.1 per cent of bread is carbohydrates the percentage of carbohydrates which the body will obtain from a given amount of bread will be 98 per cent of 53.1, or 52 per cent of the weight of the bread. Similarly the fuel value given is not the heat of combustion of the food consumed, but that of the nutrients actually oxidized in the body. This fuel value may be calculated from the proportions of digestible nutrients and the fuel values of each as learned by experiment.

The proportions of the several nutrients which the body retains for its use are commonly called percentages or coefficients of digestibility.[a]

From the results of a large amount of experimenting it appears that the coefficients of digestibility and the fuel value per pound of different food materials or groups of materials are approximately as follows:

TABLE II.—*Coefficients of digestibility and fuel value per pound of nutrients in different groups of food materials.*

Kind of food.	Protein.		Fat.		Carbohydrates.	
	Digestibility.	Fuel value per pound.	Digestibility.	Fuel value per pound.	Digestibility.	Fuel value per pound.
	Per cent.	*Calories.*	*Per cent.*	*Calories.*	*Per cent.*	*Calories.*
Meats and fish	97	1,940	95	4,040	98	1,730
Eggs	97	1,980	95	4,090	98	1,730
Dairy products	97	1,940	95	3,990	98	1,730
Animal food (of mixed diet)	97	1,940	95	4,050	98	1,730
Cereals	85	1,750	90	3,800	98	1,860
Legumes (dried)	78	1,570	90	3,800	97	1,840
Sugars	....	....	....	....	98	1,750
Starches	....	....	....	....	98	1,860
Vegetables	83	1,410	90	3,800	95	1,800
Fruits	85	1,520	90	3,800	90	1,630
Vegetable foods (of mixed diet)	84	1,840	90	3,800	97	1,820
Total food (of mixed diet)	92	1,820	95	4,050	97	1,820

The figures of Table III (p. 28) show the digestible nutrients and available energy in a number of common food materials, as computed from the figures in Table I, by use of the factors given in Table II. The further assumption is made that 75 per cent of the ash is digestible. The figures in the third column of Table III show the total quantity of indigestible nutrients. The term used as the heading of the last column, "nutritive ratio," or, as it is sometimes and perhaps more accurately called, "nutrient ratio," requires a word of explanation. The term nutritive ratio is used to express the ratio of digestible protein to digestible fuel ingredients (fats and carbohydrates) in any food material or diet. In calculating this ratio 1 pound of fat is taken as equivalent to 2¼ pounds of carbohydrates—this being approximately the ratio of their fuel values—so that the nutritive ratio is actually that of the protein to the carbohydrates plus 2¼ times the fat.

[a] It should be understood that the terms "digestibility" and "digestible nutrients" and "coefficients of digestibility," as used in the following tables and the accompanying explanations, refer to apparent digestibility (see p. 22).

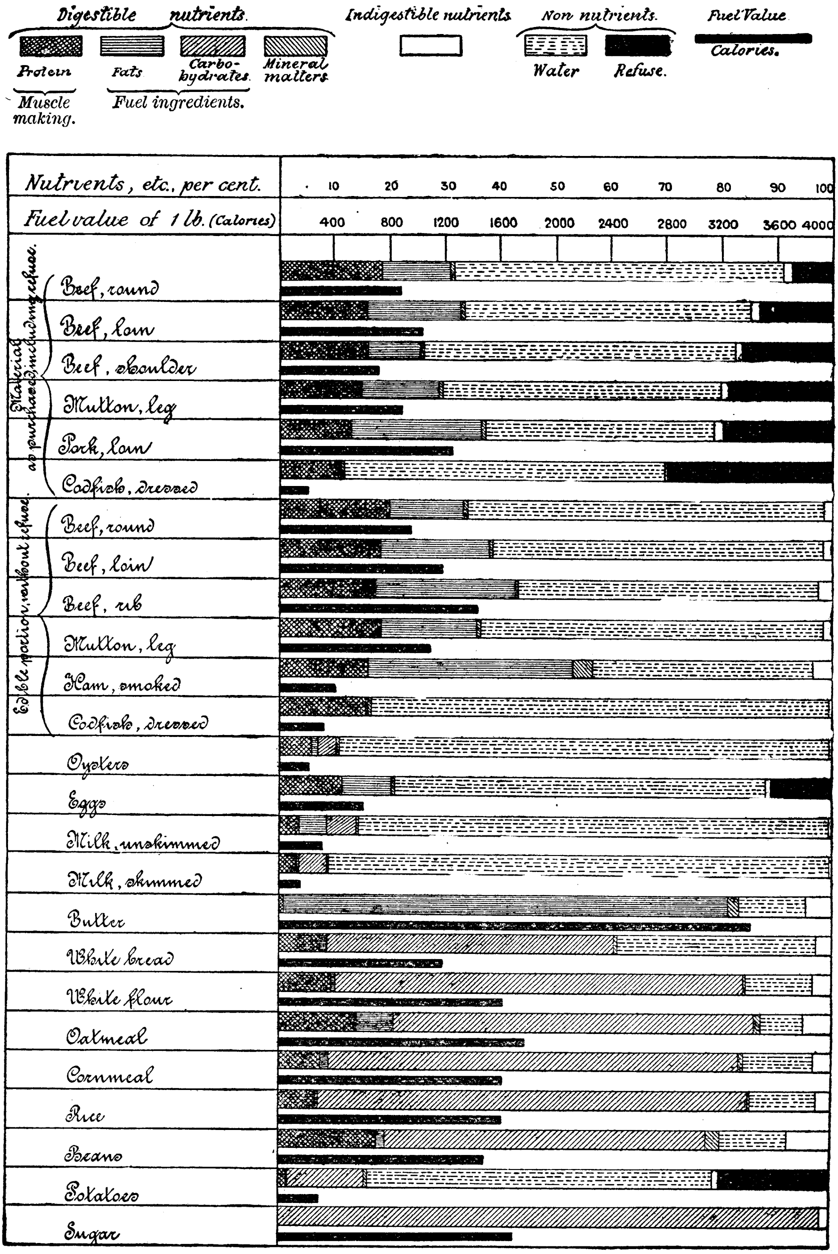
Table III.—*Nutrients and energy of digestible portion of some common foods, with nutritive ratios.*

Kind of food materials.	Refuse.	Water.	Total indigestible nutrients.	Digestible nutrients. Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.	Nutritive ratio.
ANIMAL FOOD.									
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*	*1:*
Beef, fresh:									
Chuck, ribs	16.3	52.6	1.4	15	14.3	....	0.6	910	2.1
Loin, medium	13.3	52.5	1.6	15.6	16.6	....	.7	1,025	2.4
Ribs	20.8	43.8	1.8	13.5	20	....	.5	1,135	3.3
Round, medium	7.2	60.7	1.4	18.4	12.2	....	.8	890	1.5
Shoulder and clod	16.4	56.8	1.2	15.9	9.3	....	.7	715	1.3
Beef, dried and smoked	4.7	53.7	4.5	25.6	6.6	....	5.5	790	.6
Veal:									
Cutlets, round	3.4	68.3	1.2	19.5	7.1	....	.8	695	.8
Leg	14.2	60.1	1.1	15	7.5	....	.7	625	1.1
Mutton:									
Leg	18.4	51.2	1.4	14.6	14	....	.6	890	2.2
Loin	16	42	2	13.1	26.9	....	.5	1,415	4.6
Pork, fresh:									
Loin, chops	19.7	41.8	1.8	13	23	....	.6	1,245	4
Ham	10.7	48	1.9	13.1	24.6	....	.6	1,320	4.2
Pork, salted and smoked:									
Bacon	7.7	17.4	4.4	8.8	59.1	....	3.1	2,720	15.1
Ham	13.6	34.8	3.1	13.8	31.7	....	3.2	1,635	5.2
Salt, fat	....	7.9	5.4	1.8	81.9	....	2.9	3,555	....
Poultry:									
Fowl	25.9	47.1	1.2	13.3	11.7	....	.5	765	2
Turkey	22.7	42.4	1.6	15.6	17.5	....	.6	1,060	2.5
Fish, fresh:									
Cod, dressed	29.9	58.5	.5	10.8	.2	....	.6	220	.1
Mackerel	44.7	40.4	.7	9.9	4	....	.5	370	.9
Shellfish:									
Oysters, solids	....	88.3	.6	5.8	1.2	3.3	.8	225	1
Fish, preserved and canned:									
Cod, salt	24.9	40.2	5.1	15.5	.4	....	13.9	325	.1
Salmon, canned	....	63.5	1.9	21.1	11.5	....	2	915	1.2
Eggs, uncooked	11.2	65.5	1.1	12.7	8.8	....	.7	635	1.7
Dairy products:									
Whole milk	....	87	.5	3.2	3.8	5	.5	310	4.3
Skim milk	....	90.5	.3	3.3	.3	5.1	.5	165	1.8
Cream	....	74	1.1	2.4	17.6	4.5	.4	865	18.4
Butter	....	11	4.9	1	80.8	....	2.3	3,410	....
VEGETABLE FOOD.									
Cereals, etc.:									
Corn meal	....	12.5	3.3	7.8	1.7	73.9	.8	1,640	10
Oat breakfast food	....	7.8	5.1	14.2	6.6	64.9	1.4	1,800	5.6
Rye flour	....	12.9	2.9	5.8	.8	77.1	.5	1,620	13.6
Rice	....	12.3	2.9	6.8	.3	77.4	.3	1,625	11.5
Wheat flour, patent process	....	12	3.4	9.7	.9	73.6	.4	1,635	7.8
Wheat breakfast food	....	9.6	3.8	10.3	1.6	73.7	1	1,680	7.5
Bread, etc.:									
Bread, white wheat	....	35.3	2.9	7.8	1.2	52	.8	1,200	7
Crackers, cream	....	6.8	4.5	8.2	10.9	68.3	1.3	1,925	11.3
Vegetables:									
Beans, white, dried	....	12.6	7.9	17.5	1.6	57.8	2.6	1,520	3.5
Beets, fresh	20	70	.8	1.1	.1	7.3	.7	160	6.8
Cabbage	15	77.7	.6	1.2	.2	4.6	.7	115	4.2
Potatoes	20	62.6	1.2	1.5	.1	14	.6	295	9.5
Squash	50	44.2	.4	.6	.2	4.3	.3	100	7.8
Sweet potatoes, fresh	20	55.2	1.6	1.2	.5	20.8	.7	440	18.3
Tomatoes	....	94.3	.5	.7	.4	3.7	.4	95	6.6
Fruits:									
Apples	25	63.3	1.2	.3	.3	9.7	.2	190	34.7
Bananas	35	48.9	1.6	.7	.4	12.9	.5	260	19.7
Grapes	25	58	1.7	.9	1.1	13	.3	295	17.2
Oranges	27	63.4	1	.5	.1	7.7	.3	150	15.8
Strawberries	5	85.9	1	.8	.5	6.3	.5	150	9.3

The principal data included in Table III are shown in graphic form in Chart 1.

CHART 1.—COMPOSITION OF FOOD MATERIALS.

Nutritive ingredients, refuse, and fuel value.



It is to be observed that the values given in Table III, like those of Table I, represent averages. Different specimens of the same kind of food material differ in composition, digestibility, and nutritive value. Materials which are grouped in the same class may also differ more or less in this respect. Thus potatoes, turnips, cabbage, or even different specimens of the same vegetable, may differ in the proportions of nutrients digested. The figures in Table III, therefore, are to be taken as only approximate values.

PREPARATION OF FOOD—COOKING.

The cooking of food has much to do with its nutritive value. Many articles which, owing to their mechanical condition or other cause, are quite unfit for nourishment when raw are very nutritious when cooked. It is also a matter of common experience that a well-cooked food is wholesome and appetizing, while the same material badly cooked is unpalatable. There are three chief purposes of cooking. The first is to change the mechanical condition so that the digestive juices can act upon the food more freely. Heating often changes the structure of food materials very materially, so that they are more easily chewed and more easily and thoroughly digested. The second is to make it more appetizing by improving the appearance or flavor, or both. Food which is attractive to the taste quickens the flow of saliva and other digestive juices, and thus digestion is aided. The third is to kill by heat any disease germs, parasites, or other dangerous organisms it may contain. This is often a very important matter, and applies to both animal and vegetable foods.

The cooking of meats develops the pleasing taste and odor of extractives and that due to the browned fat and tissues and softens and loosens the protein (gelatinoids) of the connective tissues, and thus makes the meat more tender. Extreme heat, however, tends to coagulate and harden the albuminoids of the lean portions, and also weakens the flavor of extractives. If the heating is carried too far a burned or charred product of bad flavor results.

Meats lose weight in cooking. A small part of this is due to escape of meat juices and fat, but the chief part of the material lost is simply water. The nutritive value of a meat soup depends upon the substances which are dissolved out of the meat, bones, and gristle by the water. In ordinary meat broth these consist almost wholly of extractives and salts, which are very agreeable and often most useful as stimulants, but have little or no value as actual nutriment, since they neither build tissue nor yield energy. The principles which underlie the cooking of fish are essentially the same as with meats.

In many vegetables the valuable carbohydrates, chiefly microscopic starch grains, are contained in tiny cells with thick walls on which the

digestive juices have little effect. The heat of cooking, especially with the aid of water, ruptures these walls and also makes the starch more soluble. The heat also caramelizes a portion of the carbohydrates and produces agreeable flavors in this and other ways.

In breads, cakes, pastry, and other foods prepared from flour, the aim is to make a palatable and lighter porous substance more easily broken up in the alimentary canal than the raw materials could be. Sometimes this is accomplished simply by means of water and heat. The heat changes part of the water in the dough into steam, which, in trying to escape, forces the particles of dough apart. The protein (gluten) of the flour stiffens about the tiny bubbles thus formed and the mass remains porous even after the steam has escaped. More often, however, other things are used to "raise" the dough—such as yeast and baking powder. The baking powder gives off the gas carbon dioxid and the yeast causes fermentation in the dough by which carbon dioxid is produced. This acts as the steam does, only much more powerfully. When beaten eggs are used, the albumen incloses air in bubbles which expand, and the walls stiffen with the heat and thus render the food porous.

Scrupulous neatness should always be observed in keeping, handling, and serving food. If ever cleanliness is desirable, it must be in the things we eat, and every care should be taken to insure it for the sake of health as well as of decency. Cleanliness in this connection means not only absence of visible dirt, but freedom from undesirable bacteria and other minute organisms, and from worms and other parasites. If food, raw or cooked, is kept in dirty places, peddled from dirty carts, prepared in dirty rooms and in dirty dishes, or exposed to foul air, disease germs and other offensive and dangerous substances can easily get in.

Food and drink may, in fact, be very dangerous purveyors of disease. The bacteria of typhoid fever sometimes find their way into drinking water, and those of typhoid and scarlet fevers and diphtheria into milk, and bring sickness and death to large numbers of people. Oysters which are taken from the salt water where they grow and "floated" for a short time in brackish water near the mouth of a stream, have been known to be infected by typhoid fever germs brought into the stream by the sewage from houses where the dejections from patients had been thrown into the drains. Celery or lettuce grown in soil containing typhoid germs has been thought to convey this disease.

Food materials may also contain parasites, like tapeworms in beef, pork, and mutton, and trichinæ in pork, which are often injurious and sometimes deadly in their effect. This danger is not confined to animal foods. Vegetables and fruits may become contaminated with

eggs of numerous parasites from the fertilizers applied to them. Raw fruits and vegetables should always be very thoroughly washed before serving if there is any doubt as to their cleanliness. If the food is sufficiently heated in cooking, all organisms are killed.

Sometimes food undergoes decomposition in which injurious chemical compounds, so-called ptomaines, are formed. Poisoning by cheese, ice cream, preserved fish, canned meats, and the like has been caused in this way. The ptomaines often withstand the heat of cooking.

In some cases it has been found that foods are adulterated with compounds injurious to health; but sophistication in which harmless articles of inferior cost or quality are added is more common.

Dainty ways of serving food have a usefulness beyond their æsthetic value. Everyone knows that a feeble appetite is often tempted by a tastefully garnished dish, when the same material carelessly served would seem quite unpalatable. Furthermore, many cheap articles and "left-overs" when well seasoned and attractively served may be just as appetizing as dearer ones, and will usually be found quite as nutritious.

DIETARIES AND DIETARY STANDARDS.

The information gained from a study of the composition and nutritive value of foods may be turned to practical account by using it in planning diets for different individuals or classes of individuals or in estimating the true nutritive value of the food actually consumed by families or individuals. By comparing the results of many such investigations with the results of accurate physiological experimenting it is possible to learn about how much of each of the nutrients of common foods is needed by persons of different occupations and habits of life, and from this to compute standards representing the average requirements for food of such persons.

METHODS OF MAKING DIETARY STUDIES.

During the last twenty years much of this practical application of the chemistry of food has been made in the study of actual dietaries. Much work of this kind has been done in England, Germany, Italy, Russia, Sweden, and elsewhere in Europe, and in Japan and other oriental countries. Within the past dozen years extensive studies have been made in the United States. The simplest way of making such inquiries is to find out what kinds and quantities of food are used during a given period in the household in which the study is made; to estimate the amounts of various nutrients which the different materials contain by means of figures given for the average composition of the various articles in tables, like Table I (p. 16), and then to calcu-

late the cost and amount of nutrients for each person. There are, however, several chances for error in such a method. In the first place, since different specimens of the same kind of food vary greatly in composition, it is often inaccurate to estimate the nutrients of one specimen from figures representing the average composition. Accordingly, in the more careful dietary studies, the composition of the food is determined by analyzing samples of materials actually used. Again, this method assumes that all the food is really consumed, whereas it is very plain that frequently no small portion is wasted in the kitchen or at the table. This difficulty is usually met by measuring and computing the amounts of nutrients in the waste and sometimes by analyzing samples of it.

In preparing the results of dietary studies so that different studies may be compared, another difficulty appears. For example, in a family consisting of father, mother, and two children of different ages the amount of food taken by each is by no means the same, and it would be quite incorrect to divide the whole amounts consumed by four and call the result the amount used per person. Men, as a rule, eat more than women, women more than young children, and persons of active habits more than those who take little muscular exercise. A coal heaver, who is constantly using up nutritive material of muscular tissue to supply the energy required for his severe muscular work, needs a diet with more protein and higher fuel value than a bookkeeper who sits at a desk all day. It is ordinarily estimated that, as compared with a man at moderate or light work, a woman under similar conditions needs 0.8 as much food, and children amounts varying with their ages, and such figures are used to reduce the statistics of a dietary to the standard of one man at moderate work. The various factors commonly used in the United States in computing the results of dietary studies are as follows:

Factors used in calculating meals consumed in dietary studies.

Man at hard muscular work requires 1.2 the food of a man at moderately active muscular work.

Man with light muscular work and boy 15–16 years old require 0.9 the food of a man at moderately active muscular work.

Man at sedentary occupation, woman at moderately active work, boy 13–14, and girl 15–16 years old require 0.8 the food of a man at moderately active muscular work.

Woman at light work, boy 12, and girl 13–14 years old require 0.7 the food of a man at moderately active muscular work.

Boy 10–11 and girl 10–12 years old require 0.6 the food of a man at moderately active muscular work.

Child 6–9 years old requires 0.5 the food of a man at moderately active muscular work.

Child 2-5 years old requires 0.4 the food of a man at moderately active muscular work.

Child under 2 years old requires 0.3 the food of a man at moderately active muscular work.

These factors are based in part upon experimental data and in part upon arbitrary assumptions. They are subject to revision when experimental evidence shall warrant more definite conclusions.

In making dietary studies in this country blanks are usually prepared to be filled out with statistics of the amounts, kinds, cost, and estimated nutrients of the food purchased, wasted, and actually consumed, and information concerning the number, sex, age, and occupation of the persons for whom the food is provided. If further data are gathered concerning the health, nationality, income, and general conditions of the individuals of families, the results of such inquiries have a wider physiological and sociological bearing. These supplementary statistics have been collected in considerable detail in late studies in the United States.

AMERICAN AND EUROPEAN DIETARIES AND DIETARY STANDARDS.

Many interesting things come to light on comparing the dietaries of persons with different occupations and incomes and performing different amounts of muscular work. A comparison of the dietaries of the inhabitants of different countries is also interesting. Such comparisons are made in the following table, which includes as well the commonly accepted dietary standards. The figures show the quantities of both total and available nutrients. The fuel value represents the actual amount of available energy, and may be computed from either the total or the digestible nutrients by use of appropriate factors.[a]

TABLE IV.—*Food consumption of persons in different circumstances, and proposed dietary standards.*

[Quantities per man per day.]

	Number of studies included in averages.	Actually eaten.			Digestible.			Fuel value.	Nutritive ratio.
		Protein.	Fat.	Carbohydrates.	Protein.	Fat.	Carbohydrates.		
PERSONS WITH ACTIVE WORK.		*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Calories.*	*1:*
Rowing clubs in New England	7	155	177	440	143	168	427	3,955	5.6
Bicyclists in New York	3	186	186	651	171	177	631	5,005	6
Football teams in Connecticut and California	2	226	354	634	208	336	615	6,590	6.6
Prussian machinists	1	139	113	677	128	107	657	4,270	7
Swedish mechanics	5	189	110	714	174	104	693	4,590	5.3
PERSONS WITH ORDINARY WORK.									
Farmers' families in eastern United States	10	97	130	467	89	124	453	3,415	8.2
Mechanics' families in United States	14	103	150	402	95	143	390	3,355	7.5

[a] These factors are as follows: For each gram of total nutrients, protein 4.0, fat 8.9, and carbohydrates 4.0 calories. For each gram of digestible nutrients, protein 4.4, fat 9.4, and carbohydrates 4.1 calories.

Table IV.—*Food consumption of persons in different circumstances, and proposed dietary standards*—Continued.

	Number of studies included in averages.	Actually eaten.			Digestible.			Fuel value.	Nutritive ratio.
		Protein.	Fat.	Carbohydrates.	Protein.	Fat.	Carbohydrates.		
PERSONS WITH ORDINARY WORK—continued.									
		Gms.	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Calories.*	*1:*
Laborers' families in large cities of United States	12	101	116	344	93	110	334	2,810	6.3
Laborers' families in United States (more comfortable circumstances)	2	120	147	534	110	140	518	3,925	7.6
Russian peasants	......	129	33	589	119	31	571	3,165	5.4
Swedish mechanics	6	134	79	523	123	75	507	3,330	5.5
PROFESSIONAL MEN.									
Lawyers, teachers, etc., in United States	14	104	125	423	96	119	410	3,220	7.1
College clubs in United States	15	107	148	459	98	141	445	3,580	7.8
German physicians	2	131	95	327	121	90	317	2,680	4.3
Japanese professor	1	123	21	416	113	19	403	2,345	4
MEN WITH LITTLE OR NO EXERCISE.									
Men (American) in respiration calorimeter	11	112	80	305	103	76	296	2,380	4.5
Men (German) in respiration apparatus	5	127	80	302	117	76	293	2,430	4
PERSONS IN DESTITUTE CIRCUMSTANCES.									
Poor families in New York City	11	93	95	407	86	90	395	2,845	6.9
Laborers' families in Pittsburg, Pa	2	80	95	308	74	90	299	2,400	6.8
German laborer's family	1	52	32	287	48	30	278	1,640	7.2
Italian mechanics	5	76	38	396	70	36	384	2,225	6.6
MISCELLANEOUS.									
Negro families in Alabama and Virginia	39	86	145	440	79	138	427	3,395	9.3
Italian families in Chicago	4	103	111	391	95	105	379	2,965	6.5
French Canadians in Chicago	5	118	158	345	109	150	335	3,260	6.2
Bohemian families in Chicago	8	115	101	360	106	96	349	2,800	5.3
Inhabitants Java village, Columbian Exposition, 1893	1	66	19	254	61	18	246	1,450	4.7
Russian Jews in Chicago	10	137	103	418	126	98	405	3,135	5
Mexican families in New Mexico	4	94	71	613	86	67	595	3,460	8.7
Chinese dentist in California	1	115	113	289	106	107	280	2,620	4.9
Chinese laundryman in California	1	135	76	566	124	72	549	3,480	5.7
Chinese farm laborer in California	1	144	95	640	132	90	621	3,980	6.2
United States Army ration, peace	......	120	161	454	110	153	440	3,730	7.1
German army ration, peace	......	114	39	480	105	37	466	2,725	5.2
DIETARY STANDARDS.									
Man at hard work (Voit)	......	145	100	450	133	95	437	3,270	4.9
Man at moderate work (Voit)	......	118	56	500	109	53	485	2,965	5.5
Man with very hard muscular work (Atwater)	......	175	(a)	(a)	161	(a)	(a)	5,500	7.2
Man with hard muscular work (Atwater)	......	150	(a)	(a)	138	(a)	(a)	4,150	6.2
Man with moderately active muscular work (Atwater)	......	125	(a)	(a)	115	(a)	(a)	3,400	6.2
Man with light to moderate muscular work (Atwater)	......	112	(a)	(a)	103	(a)	(a)	3,050	6.1
Man at "sedentary" or woman with moderately active work (Atwater)	......	100	(a)	(a)	92	(a)	(a)	2,700	6.1
Woman at light to moderate muscular work, or man without muscular exercise (Atwater)	......	90	(a)	(a)	83	(a)	(a)	2,450	6.1

[a] Fats and carbohydrates in sufficient amounts to furnish, together with the protein, the indicated amount of energy.

The dietary standards[a] given in the table (pp. 34, 35) are based, as far as possible, upon the results of observation and experiment, but are at best general estimates and not guides to be blindly followed. They are subject to revision in the light of further experimental evidence. It will be observed that the amounts of energy provided in the American standards are somewhat larger than in the European standards (Voit's). This corresponds to the observed fact that people in this country, more especially the working people, are as a rule better fed and do more work than those of corresponding classes in Europe. The quantities of protein in these standards are larger in proportion to the fuel ingredients—that is, the nutritive ratio is narrower—than is found in the average American diet. In this respect the standards agree more nearly with the diet of well-to-do people in Europe. It is believed that the larger amount of protein represents rather more nearly a physiological ration than do the proportions as found in the majority of actual dietaries.

The results of a large amount of experimental investigation bear out the common belief that the American, as a rule, uses more food than the European of the same class. The character of the food is, however, quite different. The poor peasants of Russia and northern Germany live chiefly upon rye bread, potatoes, and some sort of fat. In Italy maize, chestnuts, and acorn meal form an important item in the diet of a considerable portion of the poorer population. The use of meat among the working population of most European and Asiatic countries is very much less general than in America, because its cost is prohibitive.

In the majority of European dietaries the fats occur in relatively smaller and carbohydrates in relatively larger amounts than in American dietaries. This is probably due in large measure to the smaller quantities of meats used in the former dietaries.

Among the more scantily nourished peoples of the globe are the poor of India and China. They live largely on rice and other cereals and vegetables, with more or less of pulse and other legumes, and often on quantities which to the ordinary American would seem little more than a starvation diet.

A close examination of the detailed statistics from which those of Table III (p. 28) have been selected shows that, although there may be occasional wide variations between two individuals of a given class in respect to the total amounts of food eaten, yet, on the whole, through extended periods, there are not unusually large variations in amounts of protein or energy in the food consumed by different individuals of the same class; that is, under similar conditions as regards work or rest.

[a]For several years an effort has been made to collect statistical and experimental data with a view to revising dietary standards. The amount of data at present (1906) available is very large, and the work of systematizing it is well under way. It seems probable that the revised dietary standards will differ somewhat from the standards published in this and earlier publications of this Department.

MAKING HOME STUDIES OF DIETARIES.

Any housekeeper who wishes to know how the nutritive value of the food she provides for her family corresponds with the dietary standards can easily make a simple dietary study in her home, and by so doing can perhaps not only provide meals that are more in accordance with the needs of her family, but frequently also save money by substituting less expensive but equally nutritious and attractive food materials for some of those usually served.

The simplest way to make such a study is to weigh all different kinds of food materials in the house at a given time, say after supper, recording the weights in a convenient book. All the food purchased during the days during which the diet is being studied is weighed and recorded, and at the close of the study, which may be conveniently of seven or ten days' duration, all food materials remaining on hand are weighed as before. From the quantities of the different kinds of food on hand at the beginning and purchased during the period are subtracted the quantities left on hand at the close of the study. The difference represents the amounts used. The quantity of nutrients in the different materials is calculated from the figures for percentage composition given in Table I, or in other more comprehensive tables[a]. In order to express the quantities of nutrients in values per man per day, the number of meals taken by different members of the family are multiplied by the factors given on page 33, pointing off one decimal place. The result gives the equivalent number of meals for a man. The equivalent number of meals taken divided by 3 gives the equivalent number of days for one man. The total nutrients for the whole period, divided by this latter quantity, gives the nutrients per man per day. From these latter figures the fuel value of the diet can be computed by means of the factors given on page 33. In a similar way the value of any menu for one day or one meal may be calculated. It is to be remembered that in a short period, such as a day or two days, the diet may fluctuate according to the materials used so as to give more of one kind of nutrients and less of another, or more or less total nutrients than the average diet, while in periods of a week or ten days the diet is more likely to approach an average.

ADAPTING FOOD TO THE NEEDS OF THE BODY.

All persons are alike in that they must have protein for the building and repair of the bodily machine and fuel ingredients for warmth and work, but individuals differ in the amounts and proportions they require, and even among those in good health there are many who are obliged to avoid certain kinds of food, while invalids and people with weak digestion must often have special diet.

[a]See especially U. S. Dept. Agr., Office of Experiment Stations Bul. 28, revised.

For people in good health and with good digestion there are two important rules to be observed in the regulation of the diet. The first is to choose the things which "agree" with them, and to avoid those which they can not digest and assimilate without harm. The second is to use such kinds and amounts of food as will supply all the nutrients the body needs and at the same time avoid burdening it with superfluous material to be disposed of at the cost of health and strength.

For guidance in this selection, nature provides us with instinct, taste, and experience. Physiological chemistry adds to these the knowledge—still new and far from adequate—of the composition of food and the laws of nutrition. In our actual practice of eating we are apt to be influenced too much by taste—that is, by the dictates of the palate; we are prone to let natural instinct be overruled by acquired appetite, and we neglect the teachings of experience. We need to observe our diet and its effects more carefully and to regulate appetite by reason. In doing this we may be greatly aided by the knowledge of what our food contains and how it serves its purpose in nutrition.

Though there may be differences among abnormal persons, for the great majority of people in good health the ordinary food materials—meats, fish, eggs, milk, butter, cheese, sugar, flour, meal, and potatoes and other vegetables—make a fitting diet, and the main question is to use them in the kinds and proportions fitted to the actual needs of the body.

When more food is eaten than is needed, or when articles difficult of digestion are taken, the digestive organs are overtaxed, if not positively injured, and much energy is thus wasted which might have been turned to better account. The evils of overeating may not be felt at once, but sooner or later they are sure to appear—perhaps in an excessive amount of fatty tissue, perhaps in general debility, perhaps in actual disease. The injurious effects of food which does not "agree" with a person have already been pointed out.

ADVANTAGES OF SEVERAL MEALS A DAY.

The theory is advanced from time to time that one or two meals a day are preferable to the three commonly served in this country. If the same amount of food is to be eaten it is hard to see the advantage of two very hearty meals over three ordinary ones. The best physiological evidence implies that moderate quantities of food taken at moderate intervals are more easily and completely digested by ordinary people than larger quantities taken at long intervals. If the food ordinarily taken is considered excessive and the aim is simply to reduce the amount, it would seem more rational to make all the meals lighter than to leave out one. The very fact that the custom of eating a number of meals a day has so long been almost universal indicates that it must have some advantages which instinct, based upon experience, approves and justifies.

PECUNIARY ECONOMY OF FOOD.

Although the cost of food is the principal item in the living expenses of a large majority of the people, and although the physical welfare of all is so intimately connected with and dependent upon diet, very few of even the most intelligent have any clear ideas regarding the actual nutriment in the different food materials they use. In too many cases even those who wish and try to economize know very little as to the combinations which are best fitted for their nourishment and have still less information as to the relation between the real nutritive value of different foods and their cost.

The question here to be considered is this: Of the different food materials which are palatable, nutritious, and otherwise suited for nourishment, what ones are pecuniarily the most economical; in other words, what ones furnish the largest amounts of available nutrients at the lowest cost? In answering this question it is necessary to take into account not only the prices per pound, quart, or bushel of the different materials, but also the kinds and amounts of the actual nutrients they contain and their fitness to meet the demands of the body for nourishment. The cheapest food is that which supplies the most nutriment for the least money. The most economical food is that which is cheapest and at the same time best adapted to the needs of the user.

There are various ways of comparing food materials with respect to the relative cheapness or dearness of their nutritive ingredients. For instance, from the proportions of available nutrients and energy in different food materials given in Table III we may calculate the cost of the different nutrients per pound and of energy per 1,000 calories in any given material for which the price per pound is known. Thus, for the different food materials given in Table V (p. 40), when the price of any material is that given in the first column, the cost of protein and energy will be as given in the second and third columns. These figures show the relative economy of the various foods as sources of protein and sources of energy. Of course the amount of energy that would be obtained in a quantity of any given material sufficient to furnish a pound of protein would vary with the amounts of fats and carbohydrates accompanying the protein; and on the other hand, the quantities of the different materials that would furnish 1,000 calories of energy would contain different amounts of protein. The figures for cost of protein leave the carbohydrates and fats out of account, and those for energy take no account of the protein. Hence the figures for either protein or energy alone give a very one-sided view of the relation between nutritive value and money cost.

A better way of estimating the relative pecuniary economy of different food materials is found in a comparison of the quantities of both nutrients and energy which can be obtained for a given sum, say 10

cents, at current prices. This also is illustrated in Table V, which follows:

TABLE V.—*Comparative cost of digestible nutrients and energy in different food materials at average prices.*

[It is estimated that a man at light to moderate muscular work requires about 0.23 pound of protein and 3,050 calories of energy per day.]

Kind of food material.	Price per pound.	Cost of 1 pound protein.[a]	Cost of 1,000 calories energy. (a)	Amounts for 10 cents. Total weight of food material.	Protein.	Fat.	Carbohydrates.	Energy.
	Cents.	*Dollars.*	*Cents.*	*Pounds*	*Pound.*	*Pound.*	*Pounds.*	*Calories.*
Beef, sirloin	25	1.60	25	0.40	0.06	0.06	....	410
Do	20	1.28	20	.50	.08	.08	....	515
Do	15	.96	15	.67	.10	.11	....	685
Beef, round	16	.87	18	.63	.11	.08	....	560
Do	14	.76	16	.71	.13	.09	....	630
Do	12	.65	13	.83	.15	.10	....	740
Beef, shoulder clod	12	.75	17	.83	.13	.08	....	595
Do	9	.57	13	1.11	.18	.10	....	795
Beef, stew meat	5	.35	7	2	.29	.23	....	1,530
Beef, dried, chipped	25	.98	32	.40	.10	.03	....	315
Mutton chops, loin	16	1.22	11	.63	.08	.17	....	890
Mutton, leg	20	1.37	22	.50	.07	.07	....	445
Do	16	1.10	18	.63	.09	.09	....	560
Roast pork, loin	12	.92	10	.83	.11	.19	....	1,035
Pork, smoked ham	22	1.60	13	.45	.06	.14	....	735
Do	18	1.30	11	.56	.08	.18	....	915
Pork, fat salt	12	6.67	3	.83	.02	.68	....	2,950
Codfish, dressed, fresh	10	.93	46	1	.11	....	....	220
Halibut, fresh	18	1.22	38	.56	.08	.02	....	265
Cod, salt	7	.45	22	1.43	.22	.01	....	465
Mackerel, salt, dressed	10	.74	9	1	.13	.20	....	1,135
Salmon, canned	12	.57	13	.83	.18	.10	....	760
Oysters, solids, 50 cents per quart	25	4.30	111	.40	.02	....	.01	90
Oysters, solids, 35 cents per quart	18	3.10	80	.56	.03	.01	.02	125
Lobster, canned	18	1.02	46	.56	.10	.01	....	225
Butter	20	20.00	6	.50	.01	.40	....	1,705
Do	25	25.00	7	.40	....	.32	....	1,365
Do	30	30.00	9	.33	....	.27	....	1,125
Eggs, 36 cents per dozen	24	2.09	39	.42	.05	.04	....	260
Eggs, 24 cents per dozen	16	1.39	26	.63	.07	.06	....	385
Eggs, 12 cents per dozen	8	.70	13	1.25	.14	.11	....	770
Cheese	16	.64	8	.63	.16	.20	.02	1,185
Milk, 7 cents per quart	3½	1.09	11	2.85	.09	.11	.14	885
Milk, 6 cents per quart	3	.94	10	3.33	.11	.13	.17	1,030
Wheat flour	3	.31	2	3.33	.32	.03	2.45	5,440
Do	2½	.26	2	4	.39	.04	2.94	6,540
Corn meal, granular	2½	.32	2	4	.31	.07	2.96	6,540
Wheat breakfast food	7½	.73	4	1.33	.13	.02	.98	2,235
Oat breakfast food	7½	.53	4	1.33	.19	.09	.86	2,395
Oatmeal	4	.29	2	2.50	.34	.16	1.66	4,500
Rice	8	1.18	5	1.25	.08	....	.97	2,025
Wheat bread	6	.77	5	1.67	.13	.02	.87	2,000
Do	5	.64	4	2	.16	.02	1.04	2,400
Do	4	.51	3	2.50	.20	.03	1.30	3,000
Rye bread	5	.65	4	2	.15	.01	1.04	2,340
Beans, white, dried	5	.29	3	2	.35	.03	1.16	3,040
Cabbage	2½	2.08	22	4	.05	.01	.18	460
Celery	5	6.65	77	2	.02	....	.05	130
Corn, canned	10	4.21	23	1	.02	.01	.18	430
Potatoes, 90 cents per bushel	1½	1.00	5	6.67	.10	.01	.93	1,970
Potatoes, 60 cents per bushel	1	.67	3	10	.15	.01	1.40	2,950
Potatoes, 45 cents per bushel	¾	.50	3	13.33	.20	.01	1.87	3,935
Turnips	1	1.33	8	10	.08	.01	.54	1,200
Apples	1½	5.00	8	6.67	.02	.02	.65	1,270
Bananas	7	10.00	27	1.43	.01	.01	.18	370
Oranges	6	12.00	40	1.67	.01	....	.13	250
Strawberries	7	8.75	47	1.43	.01	.01	.09	215
Sugar	6	....	3	1.67	....	....	1.67	2,920

[a] The cost of 1 pound of protein means the cost of enough of the given material to furnish 1 pound of protein, without regard to the amounts of the other nutrients present. Likewise the cost of energy means the cost of enough material to furnish 1,000 calories, without reference to the kinds and proportions of nutrients in which the energy is supplied. These estimates of the cost of protein and energy are thus incorrect in that neither gives credit for the value of the other.

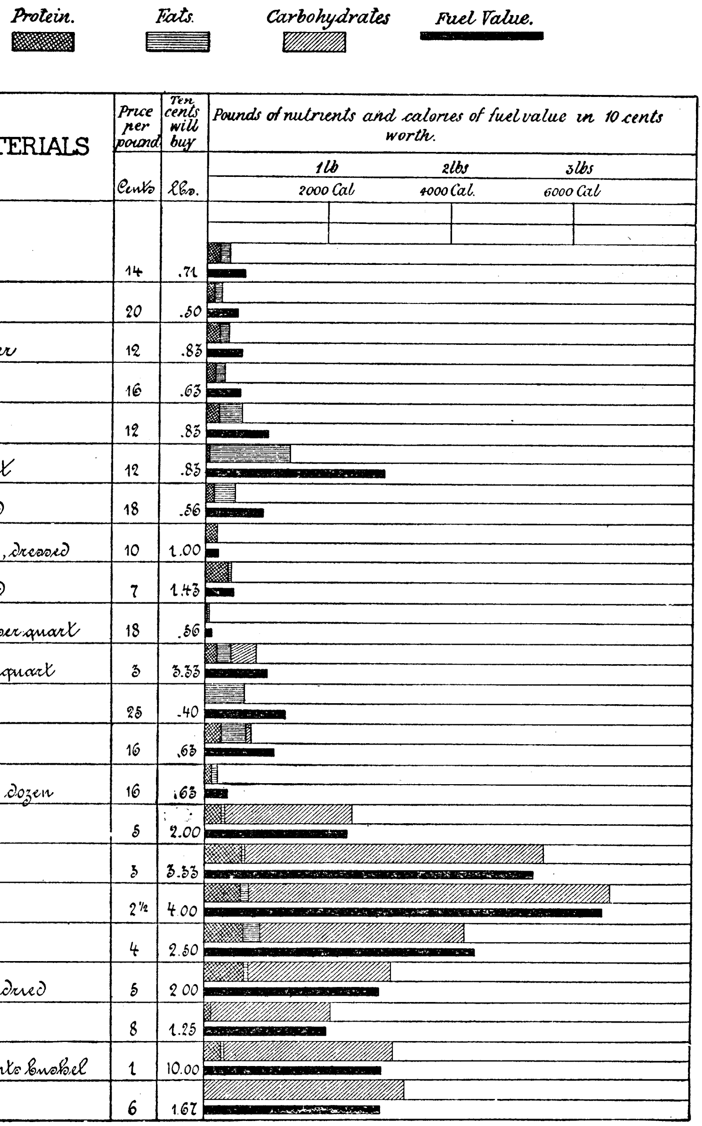
The fourth column in Table V shows the total weight of each food material and the last four columns the amounts of different nutrients and of energy that can be obtained for 10 cents when the price per pound is that given in the first column. Chart 2 illustrates graphically the facts brought out in this part of the table.

CHART 2.—PECUNIARY ECONOMY OF FOOD.

Amounts of actually nutritive ingredients obtained in different food materials for 10 cents.

[Amounts of nutrients in pounds; fuel value in calories.]

FOOD MATERIALS	Price per pound	Ten cents will buy
	Cents	Lbs.
Beef, round	14	.71
Beef, sirloin	20	.50
Beef, shoulder	12	.83
Mutton, leg	16	.63
Pork, loin	12	.83
Pork, salt, fat	12	.83
Ham, smoked	18	.56
Codfish, fresh, dressed	10	1.00
Codfish, salted	7	1.43
Oysters, 35 cts per quart	18	.56
Milk, 6 cents quart	3	3.33
Butter	25	.40
Cheese	16	.63
Eggs, 24 cents dozen	16	.63
Wheat bread	5	2.00
Wheat flour	3	3.33
Corn meal	2½	4.00
Oat meal	4	2.50
Beans, white, dried	5	2.00
Rice	8	1.25
Potatoes, 60 cents bushel	1	10.00
Sugar	6	1.67



Of course, the market prices of the different food materials would vary in different localities and at different times, but the prices here used are averages of such as are actually found in different parts of the United States in different years and seasons, and serve for comparison.

It should be borne in mind that the figures here given represent only the cost of the materials as purchased in the market. In comparing the relative economy of the different food materials no account is taken of the cost of cooking or of the convenience of preparation for the table, which are sometimes even more important from the standpoint of actual economy than the market prices.

The figures of Table V show, for instance, that 10 cents spent for beef sirloin at 20 cents a pound buys 0.5 pound of meat, which contains 0.08 pound of protein, 0.08 pound of fat, and 515 calories of energy, actually available to the body, while the same amount spent for oysters at 35 cents a quart would buy a little over half a pound of oysters, containing 0.03 pound of protein, 0.01 pound of fat, 0.02 pound of carbohydrates, and 125 calories of energy; or if spent for cabbage, at 2½ cents a pound, it would buy 4 pounds, containing 0.05 pound of protein, 0.01 pound of fat, 0.18 pound of carbohydrates, and 460 calories of energy, while of wheat flour at 3 cents a pound it would buy 3⅓ pounds, containing 0.32 pound of protein, 0.03 pound of fat, 2.45 pounds of carbohydrates, and 5,410 calories of energy. Comparing the various materials in this way, it becomes clear that the fresh vegetables are the dearest sources of protein, meats and fish somewhat cheaper, and the cereals cheapest of all; and that oysters and lobsters are the costliest sources of energy, followed by some of the green vegetables and fruits, then the majority of the meats, next potatoes, and cheapest of all, the cereals.

It is quite evident that the market price of food materials is not regulated by their actual value for nutriment. For instance, an ounce of protein or fat from the tenderloin of beef is no more nutritious than that from a round or shoulder, but it costs considerably more. The agreeableness of food to the palate or to the buyer's fancy has much to do in deciding current demand and consequent selling price. It may be said, however, that animal foods have some advantage over vegetable foods. Animal foods, such as meats, fish, milk, and the like, gratify the palate as many vegetable foods do not. Furthermore, what is of still greater weight in regulating the food habits of communities by whose demand the prices are determined, they satisfy an actual need by supplying protein and fats in which the vegetable foods, except cereal grains and leguminous seeds, are largely lacking. Moreover, as has previously been explained, the animal foods are in general more easily and completely digested than are the vegetable, especially as regards protein. Thus there is doubtless good ground for paying

somewhat more for the same total quantity of nutritive material in the animal food.

One point to be especially noted here is the difference in the cost of nutrients in foods already prepared for use and in the same materials not so prepared. For instance, wheat made into ordinary prepared breakfast cereal might contain no more available protein or energy than the same wheat made into white or graham flour, but the breakfast cereals cost more than the flour per pound. At the same time, the breakfast foods afford a pleasing variety in the diet, and often require little or no cooking and are therefore very convenient; while the flour must be made into bread or other food at more expense of labor, fuel, etc. If the breakfast cereal does not cost much more than the flour the difference may be offset by the convenience of preparation for the table, the palatability, and the pleasing variety it gives.

Many of the breakfast foods are advertised as having an especially high nutritive value. If the statements often made in advertising these could be believed they would have some nutritive property not found in flours and meals ground from the same grains. For these claims there is no ground. The breakfast foods made from wheat, corn, oats, and other cereals contain no nutritive material other than that which is in the original grain, and which is also found in the ordinary flours and meals made from the same grains; and when the two kinds of food are equally well cooked there is no experimental evidence to show any difference in the thoroughness of digestibility. The retail prices of the breakfast foods are from two to five times as large as those of the ordinary products, like flour and meal. The advertisements, which often claim nutritive values that are fictitious, do not give any suggestion of the high price of the nutrients in the prepared foods as compared with that of the same amounts in the ordinary products, nor do purchasers generally realize how expensive these prepared foods are.

ERRORS IN FOOD ECONOMY.

Scientific research, interpreting the observations of practical life, indicates that a fourfold mistake in food economy is very commonly made. First, the costlier kinds of food are used when the less expensive are just as nutritious and can be made nearly or quite as palatable. Secondly, the diet is apt to be one-sided, in that foods are used which furnish relatively too much of the fuel ingredients and too little of the flesh-forming materials. Thirdly, excessive quantities of food are used; part of the excess is eaten and often to the detriment of health; part is thrown away in the table and kitchen wastes. Finally, serious errors in cooking are committed.

For the well-to-do the worst injury is that to health; but people of small incomes suffer the additional disadvantage of the injury to purse.

Indeed, to one who looks into the matter it is surprising to see now much people of limited incomes lose in these ways. It is the poor man's money that is most injudiciously spent in the market and the poor man's food that is most badly cooked at home.

NEEDLESS USE OF EXPENSIVE FOODS.

A common mistake in purchasing food is in buying the more expensive kinds when cheaper ones would serve the purpose just as well. This is often done under the impression that there is some peculiar virtue in the costlier materials and that economy in the diet is detrimental to dignity and welfare. Unfortunately it is too often the case that those who are most extravagant in this respect are the ones who can least afford it. On the other hand, there is frequently a desire to economize, but a lack of knowledge of the best method of doing so. Many a housekeeper who sincerely tries to do the best for those to bo provided for, but whose every cent must tell, buys eggs at 25 cents a dozen, or sirloin steak at 20 cents a pound, when, for the same amount of money, it would be possible to get twice as much nourishment from a cheaper cut of meat, which, with a little skill in preparation and cooking, could be made into a tasty dish such as persons in far easier circumstances would not hesitate to set upon their tables.

The difficulty is the ignorance of the simple principles of nutrition. That ignorance results in a great waste of money. The maxim "that the best is the cheapest," as popularly understood to apply to the higher-priced materials, is not true of food. The larger part of the price of the costlier foods is paid for appearance, flavor, or rarity. While the dearer articles are often more pleasing to the palate, and are sometimes more easily cooked or possess a finer flavor, they are no more digestible nor nutritious than the cheaper ones. People who can afford them may be justified in buying them, but for persons in good health and with limited means they are not economical, and often increase the cost of food out of all proportion to nutrients furnished.

In the course of some dietary studies made in one of the poorer districts of Chicago it was found that a woman, whose husband was out of work and whose family was living on a few cents a day, bought lettuce, an article so innutritious that, at least when out of season and high in price, it is a luxury even for the rich, while she had to do without nutritious food. No one can object to the use of lettuce, or any other wholesome food, when the purse allows, but it is pitifully bad economy in such cases to buy foods which simply please the palate while the body goes without proper nourishment.

The plain, substantial, standard food materials, like the cheaper cuts of meat and fish, milk, flour, corn meal, oatmeal, beans, and potatoes, are as digestible and nutritious and as well fitted for the nourishment of people in good health as are any of the costlier materials.

We endeavor to make our diet suit our palate by paying high prices in the market rather than by skillful cooking and tasteful serving

at home. The remedy for this evil will be found in an understanding of the elementary facts regarding food and nutrition, in a better knowledge of cooking and serving food, and in the acceptance of the doctrine that economy is not only respectable but honorable.

The soup kitchens which have been established in many cities, where meals planned according to accepted dietary standards are sold at very low and yet profitable rates, should furnish their patrons with object lessons on the food-purchasing power of money.

DANGER OF A ONE-SIDED DIET.

Unless care is exercised in selecting food a diet may result which is one-sided or badly balanced—that is, one in which either protein or fuel ingredients are provided in excess. If a person consumes large amounts of meat and little vegetable food, the diet will be too rich in protein and may be harmful. On the other hand, if pastry, butter, and such foods are eaten in preference to a more varied diet, the food will furnish too much energy and too little building material.

Extreme illustrations of such a one-sided diet are found in the food of those persons who live largely on bread and tea, or others who live on corn meal, fat pork, and molasses. The "hog and hominy" diet supplies liberal quantities of energy, but is very deficient in protein, as illustrated by the diet of negroes in the "black belt," with 62 grams of protein and 3,270 calories of energy per man per day.

In this connection it should be said that most of our dietary standards have been deduced from food investigations conducted with persons living in temperate climates. It is not improbable that those living in arctic regions and in the Tropics require nutrients in different proportions. It is a matter of common observation that in arctic regions much larger amounts of energy-yielding material, principally fat, are consumed than in warmer climates. Less definite information is available regarding food requirements in the Tropics; but it seems probable that when proper dietary conditions are followed somewhat less food is consumed than in temperate regions, and that the nutrients are in somewhat different proportion. It is certain that a diet which would be entirely satisfactory in frigid regions would be one-sided in the Tropics, and vice versa. This subject is one which needs further investigation before definite conclusions can be drawn regarding the foods best fitted for extremes of heat or cold.

WASTE OF FOOD.

The use of excessive quantities of food, which is a common dietary error in this country, among not only the well to do but also those in moderate circumstances, entails a waste of food in at least three ways:

First. More food is eaten than can be properly utilized by the body. This is not universally true, for there are some people who do not eat enough for healthful nourishment. But the eating habits of large numbers are vicious, resulting not only in a loss of food material but in an increase in the labor of digestion, to say nothing of the injurious

effects which overeating may have upon the bodily organs and functions and upon health in general. Probably the worst sufferers from this evil are well-to-do people of sedentary occupations—brain workers as distinguished from hand workers.

Second. More food is served than can be eaten, and the excess is thrown away as table waste. Indeed, in many families in this country it is a matter of pride to furnish more food than is needed, a feeling which appears quite unreasonable to frugal Europeans, even those in equally comfortable circumstances.

Third. The third form is that which occurs in the preparation of food materials for consumption. Thus, in removing the inedible material, as skin, seeds, etc., from fruits and vegetables, more or less of the edible portion is removed also, depending upon the care with which the work is done. The greatest loss from a pecuniary standpoint, however, is in the waste of animal foods in which the nutrients are in their costliest forms. The "trimmings" of meat which are left with the butcher or removed in the kitchen frequently contain one-eighth of the nutritive ingredients of the material paid for. Part of such waste is inevitable, but much of the valuable nutrients might be saved if the materials were used for making soup. The more economical cuts of meats are those in which there is less waste of this kind; in such cuts of meat as loin of beef, rib chops of lamb, and similar cuts, one-fifth the cost goes to pay for bone. Such cuts, therefore, should be avoided by those who wish to get the most actual nutriment for their money.

Just where and among what classes of people the waste of food is greatest it is not possible to say, but there is certainly a great deal more of it in this country than in Europe. The worst sufferers from it are doubtless the poor, but the large body of people of moderate means, the intelligent, and fairly well-to-do wage-workers are guilty of errors in this regard. The common remark that "the average American family wastes as much food as a French family would live upon" is greatly exaggerated, but statistics show that there is considerable truth in it. In dietary studies conducted at a students' club in an Eastern college it was found that 10 to 14 per cent of the nutritive materials purchased were thrown away as kitchen or table waste, and yet the club members were trying to live as economically as was consistent with comfort. In private families the waste has been found to range from practically none to as high as 8 or 10 per cent, while in boarding houses, even where economy was sought, it has reached 10, and in individual instances 20 per cent; and in some public institutions where large numbers were fed it has been as high as 25 per cent and even higher.

ERRORS IN COOKING.

It is commonly remarked by those who study the conditions of living of people of limited means in different parts of the country that

for substantial improvement of their household economics two things are needed. They must be informed as to the high nutritive value of the cheaper foods as compared with the costlier kinds, and the methods of cooking must be improved. A great deal of fuel is wasted in the preparation of food, and even then a great deal of the food is badly cooked. To replace dear food badly cooked by cheaper food well cooked is important for both health and purse. To make the table more attractive will be an efficient means for making the home life more enjoyable.

SUMMARY.

Food has been briefly defined as "that which taken into the body, either builds tissue or yields energy." In its building function protein is the most important ingredient of food, as it is the basis of muscle, bone, and almost all the tissues and fluids of the body. Mineral matters are also needed in the body structure, though in smaller quantities. Protein, fats, and carbohydrates may any of them be burned in the body to produce heat or muscular energy, but for protein this is a less important and probably less usual function. The fats and carbohydrates, by being themselves used as fuel, leave the protein for its indispensable work of tissue forming.

Not only the amounts of nutritive ingredients which a food contains, but also the proportions which can be digested and utilized by the body, determine the real nutritive value of a food material. As a general rule, carbohydrates are more completely digested and hence more fully available for use in the body than protein and fats, and protein of animal foods, as meat, fish, milk, and eggs, is more digestible than that of vegetable foods. Fats are probablly less digestible than most forms of protein and carbohydrates.

In ordinary mixed diet the chief sources of protein are meat, fish, and milk among animal foods, and the cereals and legumes among vegetable foods. Beans, peas, and oatmeal are rich in protein and hence especially valuable food. About nine-tenths of the fat in the ordinary diet is obtained from the animal foods, while the vegetable foods furnish approximately nine-tenths of the carbohydrates.

Other things being equal, foods furnishing nutrients which can be most easily and completely utilized by the body are the most desirable, since they will not bring unnecessary exertion to the various organs. Many kinds of food which in their natural state hold the most valuable nutrients in such form that the digestive juices can not easily work upon them are so changed by the heat of cooking that they become easily digestible. Thus the importance of proper cooking can hardly be overestimated. Things which please the palate stimulate the flow of the digestive juices; for this reason food should be made appetizing. An attractive diet pleases the æsthetic sense; hence refinement in food

habits is as desirable as in other phases of our daily life. The sense of comfort and satisfaction produced by even the appearance of food well cooked and served is of indisputable value. Fortunately such satisfaction is within the reach of almost all.

Among people who have the benefits of modern comfort and culture the palate revolts against a very simple and unvaried diet, and for this reason the nutrients are usually supplied from a variety of articles—some of animal, some of vegetable origin. With a varied diet it is also easier to secure the proper proportions of protein to fats and carbohydrates.

As the habits and conditions of individuals differ, so, too, their needs for nourishment differ, and their food should be adapted to their particular requirements. It has been estimated that an average man at moderately active labor, like a carpenter or mason, should have about 115 grams or 0.25 pound of available protein and sufficient fuel ingredients in addition to make the fuel value of the whole diet 3,400 calories, while a man at sedentary employment would be well nourished with 92 grams or 0.20 pound of available protein and enough fats and carbohydrates in addition to yield 2,700 calories of energy. The demands are, however, variable, increasing or decreasing with increase or decrease of muscular work, or as other needs of the person change. Each person, too, should learn by experience what kinds of food yield him nourishment with the least discomfort, and should avoid those which do not "agree" with him.

Too much food is as bad as too little and occasions a waste of energy and strength in the body as well as a waste of nutritive material. While in the case of some foods as purchased, notably meats, some waste is unavoidable, the pecuniary loss can be diminished, both by buying those kinds in which there is the least waste, and by utilizing more carefully than is ordinarily done portions of what is usually classed as refuse. Much of the waste may be avoided by careful planning so as to provide a comfortable and appetizing meal in sufficient amount, but without excess. If strict economy is necessary, the dearer cuts of meat and the more expensive fruits and vegetables should be avoided. With reasonable care in cooking and serving, a pleasing and varied diet can be furnished at moderate cost. It should not be forgotten that the real cheapness or dearness of a food material depends not only on its market price, but also on the cost of its digestible nutrients. It should always be remembered that "the ideal diet is that combination of foods which, while imposing the least burden on the body, supplies it with exactly sufficient material to meet its wants," and that any disregard of such a standard must inevitably prevent the best development of our powers.

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